INSTRUMENTS AND AUTOMATION

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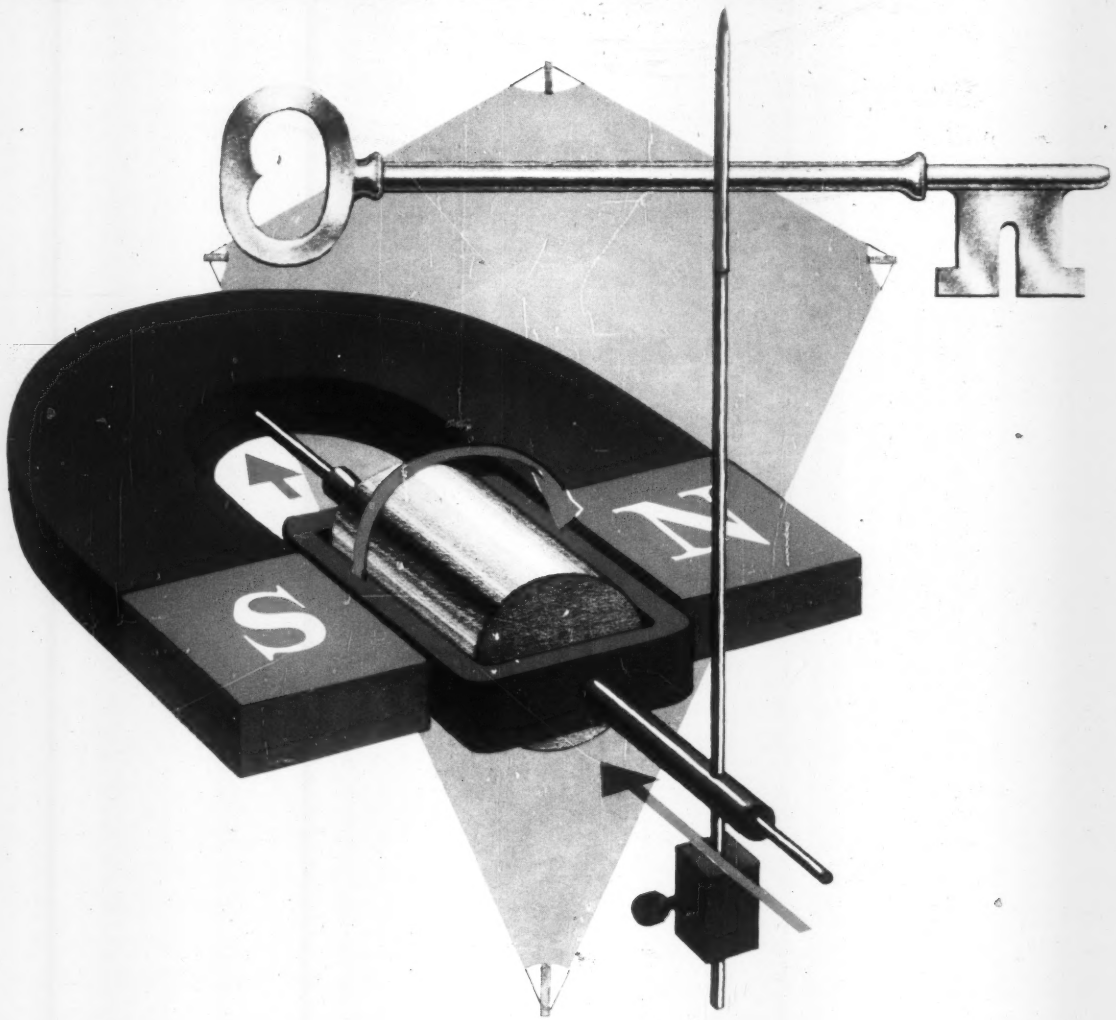
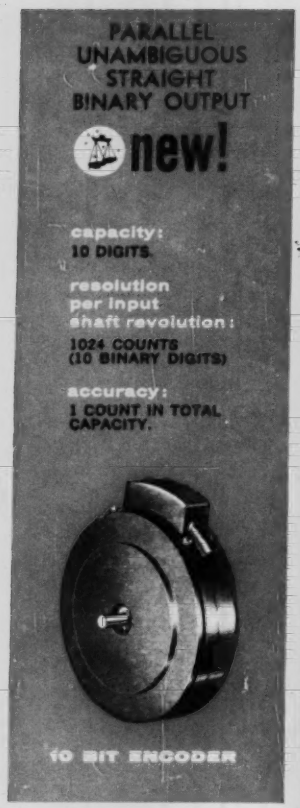
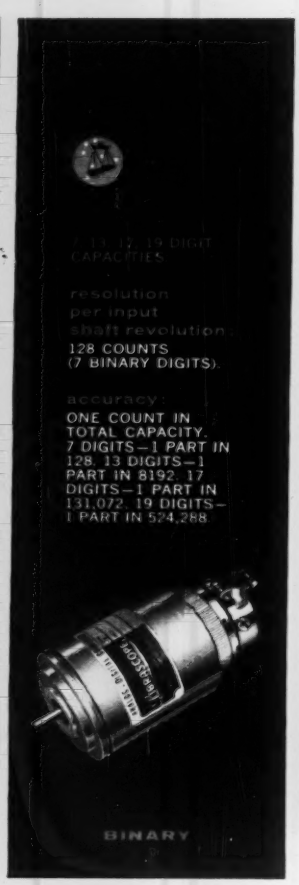


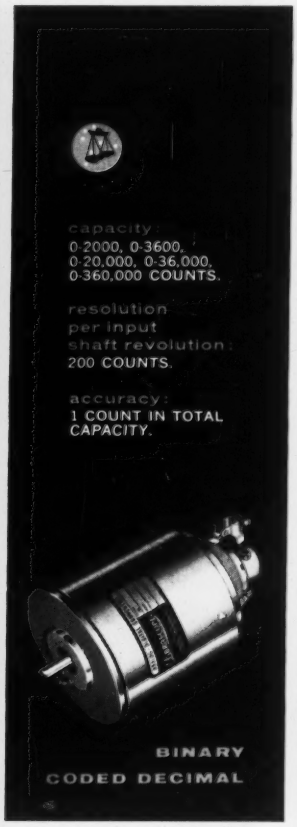
JANUARY 1959

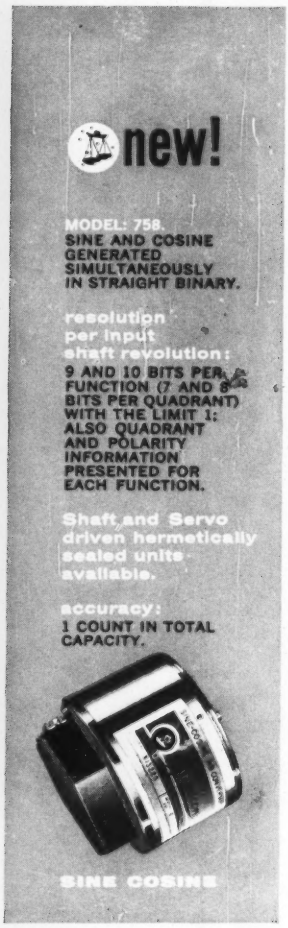
in this issue:

Accuracy Factors of Basic Movements 74
The Electrodynamometer 80
Precision Potentiometers 84
Uses of Basic Electrical Instruments 88
Setting Up A Standardization Laboratory 94
Refinements of Basic Electrical Movements 100









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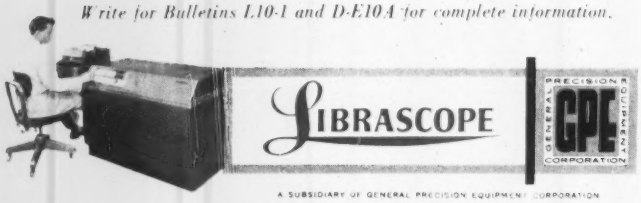

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For more information circle 1 on inquiry card.

LEWIS SELECTOR SWITCHES

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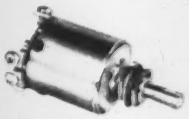
for THERMOCOUPLE THERMOMETERS

THE 9S SERIES / *The Space Savers*

Small, sturdy, steel cased switches, 1¼ inches in diameter, 2$^{9}/_{32}$ inches total shaft length, one-hole mounting with ½ inch-32 NS-2A threaded bushing. Designed especially for connecting two or more resistance bulbs to one instrument.

Part No.	Description
9S5	Single pole, four positions (with knob)
9S5B	Single pole, four positions
9S5E	Single pole, five positions
9S10	Double pole, double throw

All make before break, the instrument connected is never subjected to an open circuit during the switching operation.



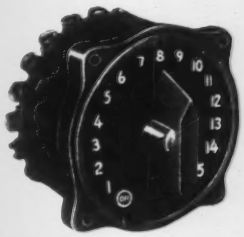
1¼ INCH SIZE

EACH SWITCH HAS "OFF" POSITION PLUS NUMBER OF POINTS LISTED.

		Switch Part Numbers	
Points	**Size**	**Thermocouple Type**	**3 Wire Resistance-Thermometer Type**
2	2″	11S2	36SR2
3	2″	11S3	36SR3
4	2″	11S4	36SR4
5	3″	10S5	37SR5
6	3″	10S6	37SR6
8	3″	10S8	37SR8
9	3″	10S9	37SR9
10	3″	10S10	37SR10
12	3″	10S12	37SR12
16	3″	10S16	37SR16
18	3″	10S18	37SR18
20	3″	10S20	37SR20
24	4″	27S24B2	38SR24
28	4″	27S28B4	38SR28
40	4″	38S2C	

(No. 38S2C is made with soldering-lug terminals)

2 INCH SIZE



3 INCH SIZE

SPECIAL SWITCHES 37S6C2, Four "4-point and OFF" thermocouple switches combined in one 3″ case.

The 44S Series, 2$^{9}/_{32}$ inches in diameter, shaft 2¼ inches, approx. One-hole mounting with ½ inch-32 NS-2A threaded bushing.

Part No.	Description
44S4	Six pole, double throw
44S7B	Double pole, four position
44S7B2	Double pole, double throw

For use with resistance thermometer, contacts make before break.

DESIGNED FOR TEST WORK AS WELL AS FOR PERMANENT INSTALLATIONS. LEWIS SELECTOR SWITCHES ARE CONSTRUCTED WITH STURDY CONTACTS OF LOW RESISTANCE AND POSITIVE DETENT. THESE SWITCHES ARE SPLASHPROOF, DUSTPROOF AND ARE BUILT TO GIVE YEARS OF SERVICE.

4 INCH SIZE

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Specialists in Electrical Temperature Measurements

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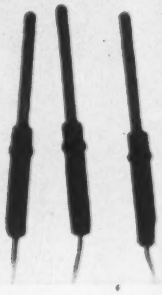

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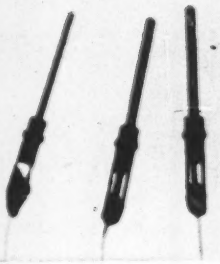


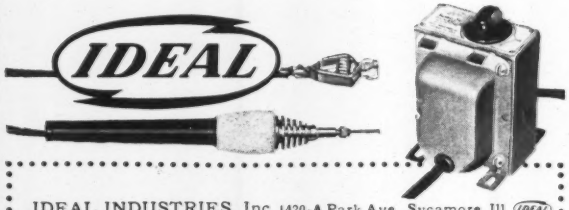
Actual X-ray Photos Show How IDEAL Thermo-Tip Resistance Soldering Tools Reduce Costly Voids in Winchester and Cannon Plug Pins

Because the whole pin is heated, "cold-flow joints" are eliminated; failures are greatly reduced

	Conduction Method		Resistance Method	
Pin No.	Length of void	% of void	Length of void	% of void
1	0.12″	40	0.00″	0
2	0.12″	40	0.00″	0
3	0.07″	23	0.05″	17
4	0.18″	60	0.00″	0
5	0.06″	20	0.06″	20
6	0.05″	17	0.04″	13
7	0.02″	7	0.05″	17
8	0.08″	27	0.01″	3
9	0.09″	30	0.07″	23
10	0.12″	40	0.09″	30
11	0.15″	50	0.04″	13
12	0.12″	40	0.06″	20
13	0.09″	30	0.01″	3
14	0.12″	40	0.08″	27
15	0.11″	37	0.02″	7
16	0.10″	33	0.04″	13
17	0.07″	23	0.04″	13
18	0.09″	30	0.09″	30
19	0.11″	37	0.10″	33
20	0.11″	37	0.06″	20
21	0.05″	17	0.01″	3
22	0.15″	50	0.00″	0
23	0.11″	37	0.05″	17
24			0.07″	23

● These production test results from a major Aircraft manufacturer prove the superiority of Ideal Resistance Soldering Tools to the best available commercial soldering irons. Voids averaged 33% with soldering irons. With resistance soldering only 14%.

In addition, higher production speeds were possible on Cannon plugs and operators were less subject to painful burns. Send for descriptive literature.



IDEAL INDUSTRIES, Inc. 1420-A Park Ave., Sycamore, Ill. (IDEAL)

Gentlemen: Please send complete catalog information about Ideal's Thermo-Tip Resistance Soldering Tools.

Name_____

Company_____

Address_____

City_____ Zone____ State_____

For more information circle **4** on inquiry card.

INSTRUMENTS AND AUTOMATION

THE MAGAZINE OF INSTRUMENTATION AND AUTOMATIC CONTROL SINCE JANUARY 1928

JANUARY 1959

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EDITORIAL

Scientific and Industrial Instrument and Apparatus Industry, 71

OUTLOOK for 1959 and review of 1958

FEATURE ARTICLES

Accuracy Factors of Basic Movements, 74

H. RUSSELL BROWNELL—commonly held beliefs are sometimes invalidated by study of factors governing accuracy

The Electrodynamometer, 80

R. F. ESTOPPEY—applications of the basic instrument for a-c and d-c/a-c measurements

Use and Maintenance Tips, 83

JOHN E. MILLER—rules for keeping instruments dependable

Precision Potentiometers, 84

M. H. ARONSON—a study of the most precise emf-measuring device available for d-c measurements

Lesser Known Uses of Basic Electrical Instruments, 88

H. R. BROWNELL, V. P. CRONIN and M. I. STEINBERG—basic electrical movements can perform many computing functions, often with startling accuracies

Local Standards Laboratories, 92

ARCHIBALD T. McPHERSON—method for facilitating decentralized standards operations

Setting Up A Standardization Laboratory, 94

P. GREENSPAN—step-by-step procedure, including tables of actual equipment used

Adaptations and Refinements of Basic Electrical Movements, 100

INCLUDE hook-on ammeters, contact-meter relays, and panel indicators

Soviet Trends In Computers For Control Of Manufacturing Processes, 102

V. B. USHAKOV—this final installment covers process control computers

Announcement on the International Yard and Pound, 106

Continued on page 4

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Bulletin P1281 gives full facts on Armorox. Complete line of Bristol Thermocouples is described in Bulletin P1238. Write: The Bristol Company, 154 Bristol Road, Waterbury 20, Conn.

8.45

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AUTOMATIC CONTROLLING, RECORDING AND TELEMETERING INSTRUMENTS

For more information circle 5 on inquiry card.

INSTRUMENTS and AUTOMATION

VOL. 32 NO. 1 • JANUARY, 1959

Continued from page 3

The Journal of
THE SOUTHERN CALIFORNIA METER ASSOCIATION

Field Test Unit For Dynamic Analysis, 108

A. BREMER—mobile field test unit measures dynamic response characteristics of plant units and control equipment

THE SIMULATION COUNCIL NEWSLETTER

Simulation Of Field Problems, 113

OTHER REGULAR FEATURES

Letters to the Editor	6	Books	57
Trends	15	New Instruments	120
News	18	New Plants and Mergers	146
Stock Report	24	People in the News	147
Briefs	30	New Literature	150
Panhandle Pete	44	Searchlite Section	158
Events	53		

Advertisers' Index 160

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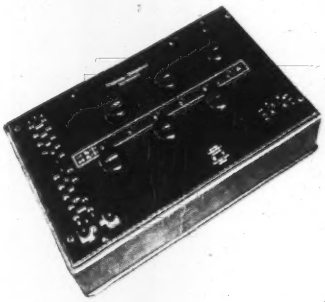
Precision Instruments by Otto Wolff



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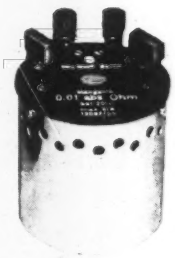

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0.5 watt to 2,250 watts. 0.00001 ohm to 25 Megohms. Accuracies from ±0.01% to ±0.002%. Sealed and unsealed, air and oil-cooled. For details, send for PRL TECHNICAL NOTE #323-SR.

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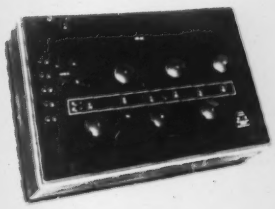

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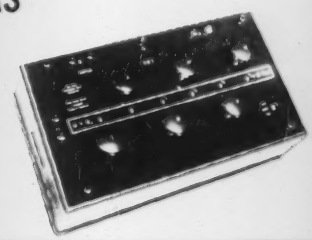
Both 5 and 6 Dial Kelvin-Varley Voltage Dividers. Terminal and Dial Type. Measurements to 10 ppm and 1 ppm. For details, send for PRL TECHNICAL NOTE #332-VB (In preparation)



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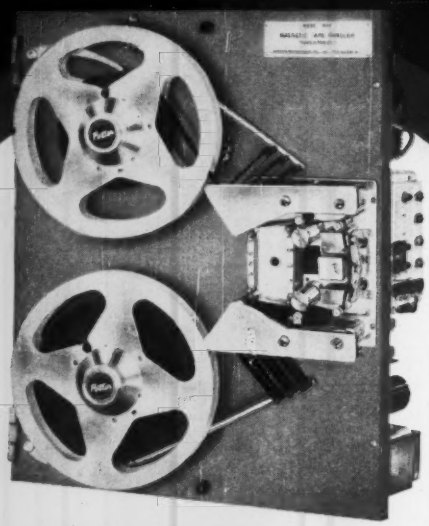

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to the editor

Editor, I&A:

Corrections, please. Location: November 1958 issue of *Instruments and Automation*, in your article, "Slide Rules."

Page 1815, column one, fifth from last line: In your illustration of a plausible mistake, you have made one. The incorrect answer obtainable by the proposed method would be $(85 \times 61/300)^2$ instead of $(85 \times 61)^2/300$.

In table 1 on the same page, you might have mentioned that the ST scale yields tangents as well as sines of angles less than 5.7° since these functions are almost equal for those angles.

Your last sentence under functions of angles on page 1816 is not entirely correct. It is true that tangents and sines of angles less than 5.71° are practically equal. However, it is the cosecants which are almost equal to tangents for angles larger than 84.29°. You might say that cosines almost equal cotagents at angles over 84.29°. Your error is obvious from the fact that sine $90° = 1$, while tan $90° = \infty$.

Why did I read so closely on a subject with which I am very familiar? I liked your presentation and wanted a quick review.

John Grissom
Welex, Inc.

We succeeded. Our objective was a good and quick review of a much neglected subject. Thanks for the polishing.

Editor, I&A:

If I raise 5.5 to the 1.4 power, I get 10.85 not 12.85 as your text states in the article "Slide Rules" in your November issue.

Miff Jacobs
Pittsburgh, Pa.

We get 10.85 too, but our printer got 12.85!

Editor, I&A:

I would like permission to copy the table found on p. 1815 of the November 58 issue of I&A. If separate reprints of the article are available (Slide Rules), this would serve the purpose.

Wendell Caley
Rochester, N. Y.

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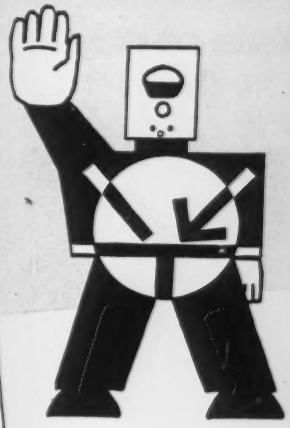

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All Others—1.0 Microvolts
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All Others—.01 ohms

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* U.S. Patent Applied For

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◄ **MODEL 1210**
1-12VDC • 0-10A
$349.50

◄ **MODEL 1010T**
1-100VDC • 0-1A
$374.50

◄ **MODEL 3235**
1-32VDC • 0-3.5A
$349.50

MODEL 105TA ►
1-100VDC • 0-500MA
$229.50

MODEL 5015 ►
1-50VDC • 0-1.5A
$249.50

WRITE FOR COMPLETE SPECIFICATIONS AND DETAILS ON OTHER MODELS

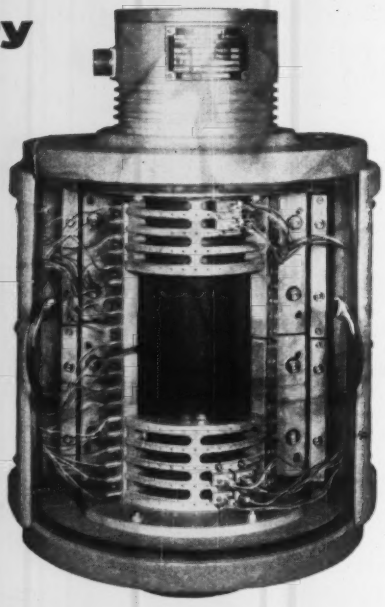
Power Designs inc.
89-25 130th STREET
RICHMOND HILL 18, N. Y.

Dual Volt-ammeter on all models except model 1515

PRICES SUBJECT TO CHANGE WITHOUT NOTICE

For more information circle **8** on inquiry card.

Improve Your Memory



with a standard multiple purpose off-the-shelf drum

The 512-A Bryant general purpose magnetic storage drum meets the exacting requirements of a production component, yet has the versatility necessary for laboratory work. This standard 5" dia. x 12" long drum is stocked for immediate shipment, complete with standard components such as general storage brackets, recirculating register brackets and magnetic read/record heads. Its low price reflects the benefits of Bryant's 25 years' experience in the efficient design and production of high speed precision spindles.

Features:

- Guaranteed accuracy of drum run-out, .00010" T. I. R. or less
- Integral drive – Bryant precision motor (1200 to 12,000 R. P. M.)
- Capacities to 625,000 bits
- Accommodates up to 240 magnetic read/record heads
- High density ground magnetic oxide coating
- Super-precision ball bearing suspension
- Vertical mounting for trouble free operation

Special Models: If your storage requirements cannot be handled by standard units, Bryant will assist you in the design and manufacture of custom-made drums. Speeds from 60 to 120,000 R. P. M. can be attained, with frequencies from 20 C. P. S. to 5 M. C. Sizes can range from 2" to 20" diameter, with storage up to 6,000,000 bits. Units include Bryant-built integral motors with ball or air bearings. Write for Model 512-A booklet, or for special information.

Remember . . . you can't beat a Bryant drum!

BRYANT COMPUTER PRODUCTS DIVISION

BRYANT CHUCKING GRINDER CO.

P. O. Box 620-I, Springfield, Vermont, U.S.A.

For more information circle 9 on inquiry card.

LETTERS—CONTINUED

Editor, I&A:

We are interested in the enquiry ref. A-338 appearing in the September 1958 issue of your magazine. Will you please communicate us the address of the concerned people?

A. Javeau
Honeywell, S. A.
Brussels, Belgium

Editor, I&A:

Referring to your insertion A-338, published in your September issue, we wish to advise that we are in a position to offer the interested company the humidity control equipment they seek. . .

H. G. Daws
Thermal Control Dept.
Van Der Heyden S. A.
Brussels, Belgium

Editor, I&A:

Having read your inquiry from a Belgian paper mill concerning moisture control in paper manufacturing, I would very much appreciate to receive more information from that potential customer in my own country. I deal mostly in measuring and controlling instruments for physical variables, nucleonic thickness gauges and statistical quality control instruments. . .

Robert Matys
Uccle, Belgium

We are widely read in Belgium!

Editor, I&A:

I like your covers—they pin point my interest and cause me to look under the cover and read a little more about the thought provoked. . . . my assistant likes the older treatment better.

John Duesing
Hagan Chemicals & Controls
Pittsburgh, Pa.

There is nothing like reader reaction to guide an editor!

Editor, I&A:

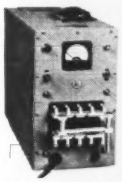
We would like to have your permission to reproduce some of the information contained in an article by James B. Williams in the April 1958 issue of your magazine.

This article on "Trends in Radiation Instrumentation" is much more up to date than the text we are cur-

RFL Test and Service Products

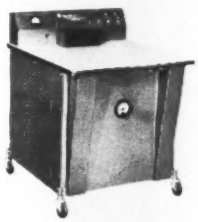
For MAGNET CHARGING, TREATING and CALIBRATION

MODEL 1221 is used for small magnets. Its 10,000 ampere-turn output will saturate about 2" of Alnico V. Operates by condenser discharge method thru plug-in fixtures. Uses only 30 watts at 115 v. For continuous duty; charging cycle averages 3 sec. Price $180.



MODEL 107A is a versatile, condenser discharge magnetizer for most medium size magnets of either simple or complex pole configuration. It provides ranges of 12,000 and 24,000 ampere-turns and is capable of saturating most instrument magnets, including the core type mechanisms, using the standard flat bar, adapters or wire-wound fixtures. Can be used for continuous duty production magnetizing; average charging cycle is under 5 sec. Weight is 75 lbs. Size 12 x 7 x 17. Operates from 115-volt, 60-cycle line. Price $530.

MODEL 1500 is designed for production, research and instrument repair work. It will magnetize the new cobalt platinum and barium ferrite materials as well as all the Alnicos. It will saturate large switchboard meter assemblies and all panel type instruments and uses most existing adapters designed for the Model 107A. Wire-wound fixtures are plugged into the front panel through a safety interlock system providing maximum operator protection. Operates from 115-volt, 60-cycle line. Size 11 x 20 x 15; weight 125 lbs. Price $945.



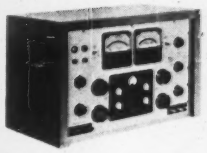
MODEL 942 will saturate Alnico magnets weighing up to 34 lbs. and high flux ceramic magnets of any shape or pole configuration. Operates on condenser discharge principle from regular 115-volt, 60-cycle line. Produces charging outputs (depending on number of 100 μf condensers employed) from 100,000 to 200,000 ampere-turns through plug-in transformers, up to 3600 watt-seconds using wire-wound fixtures. Adapters for multi-pole rotors, rod, bar, ring and various other shapes available. Equipped with extensive system of safety interlocks for complete operator protection. Designed for continuous production use with low power consumption. Price of basic unit is less than $2100.

MODEL 889A de-magnetizes saturated magnets to any desired level of flux. Provides a precision method for rapidly treating permanent magnets, including the new core type instrument mechanisms. Used with Model 206A Booster or Model 107A Charger. Price $247.

MODEL 1295 is a stable, all transistorized Gaussmeter which provides a conservative accuracy of 3% over nine full-scale ranges: 0-100, 200, 500, 1 K, 2 K, 5 K, 10 K, 20 K and 20 K + gausses, using a single probe. Two standard reference magnets having ¼% accuracy are supplied. Weight is 12 lbs. Operates from battery or 115-volt, 50-400 cycle line. Price $420.

For ELECTRICAL INSTRUMENT CALIBRATION

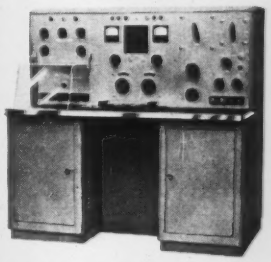
A Model for Every Purpose and Price Range



MODEL 829 checks AC and DC meters of all types and ranges. Compact cabinet contains power supply, special Weston standard meters, Wheatstone Bridge and all circuits for quick, convenient instrument calibration to 0.5% accuracy by non-technical personnel. Automatic protection for both operator and instrument under test is provided by interlocks and high voltage discharge circuits. Net price $2650.

DUAL POTENTIOMETER DC STANDARD

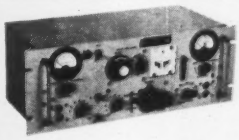
Model 262B

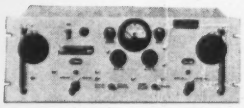


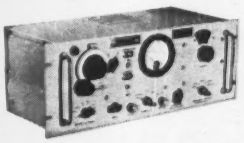
MODEL 262B Dual Potentiometer Standards for calibrating meters to 0.1% through a range of 1 millivolt to 1500 volts and 1 microampere to 150 amperes. Uses L & N Brooks Mod. 7 pot. and Weston Mod. 5 standard cells. Voltage and current ranges are separate for the calibration of wattmeters. Operates on 105/125 volts, 50/1600 cycles, 350 watts, with internal voltage regulator. Operator is protected by interlocks. Price $15,600.

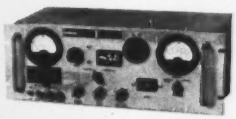
Also available are MODELS 261B and 454 Standards for calibrating AC meters to 0.5% through ranges of 10 millivolts to 1500 volts and 1 microampere to 200 amperes; MODEL 260C Standards for DC meters to 0.5% over ranges of 1 millivolt to 1500 volts and 1 microampere to 150 amperes. Accuracy of 0.25% using charts. These standards have been used for 8 years by the government services and leading industrial organizations.

For CRYSTAL TESTING









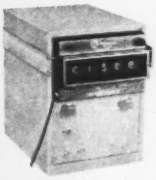
FOUR MODELS developed for Signal Corps under national crystal testing standardization program to measure resonance and anti-resonance resistance of quartz crystals including those covered by MIL-C-3098B. Capacitance, inductance and PI of crystal can be determined.

MODEL 459A (Improved TS-330/TSM) covers 800 kc to 15 mc, for 0.002% crystals, 0-9900 ohms. Operates from 115/230 v, 50-1000 cps. Price $1125.

MODEL 531 (TS-683/TSM) Crystal Impedance Meter covers range of 10-140 mc for 10-150 ohm crystals. Twelve fixed calibrating resistors of 10, 22, 30, 40, 51, 60, 68, 82, 91, 100, 120 and 150 ohms, plus a 100-ohm var. resistor for determining crystal resistance. Anti-resonance adapter also provided. Operates from 115/230 v, 50-1000 cps source. Price $590.

MODEL 541A (TS-710/TSM) for 10-1100 kc range crystals with resistances from 200 ohms to 0.5 megohms. An internal load capacitance is calibrated from 15 to 105 mmf with accuracy better than ±0.5 mmf. Power dissipated in crystal measured by built-in VTVM and ohmmeter. For 115/230 v, 50-1000 cps operation. Price $860.

MODEL 1207 (AN/TSM-15) covers range of 75-200 mc for 10-125 ohm crystals. Crystal voltage at series resonance is measured within 10%, effective resistance within ±5 ohms, and the power calculated. 18 C_0 cancellation inductances and 1 uncompensated var. resistor supplied; 5 compensated var. resistors available. 115/230 v, 50-1000 cps. Price $1245.



DIGIVERTER

DIRECT READING, digital converter fits all vertical DCU system counters; changes random vertical numerals to easy reading "in-line" display. No modifications to counter. Remote readout also available.

DIGIDEC

DIGITAL CONVERTER for individual decade counter units provides "in-line" reading for OEM installation, or in special purpose test and computing equipment. DIGIDEC mounts over neon strip; replaces mask.

Variable Frequency Power Supplies

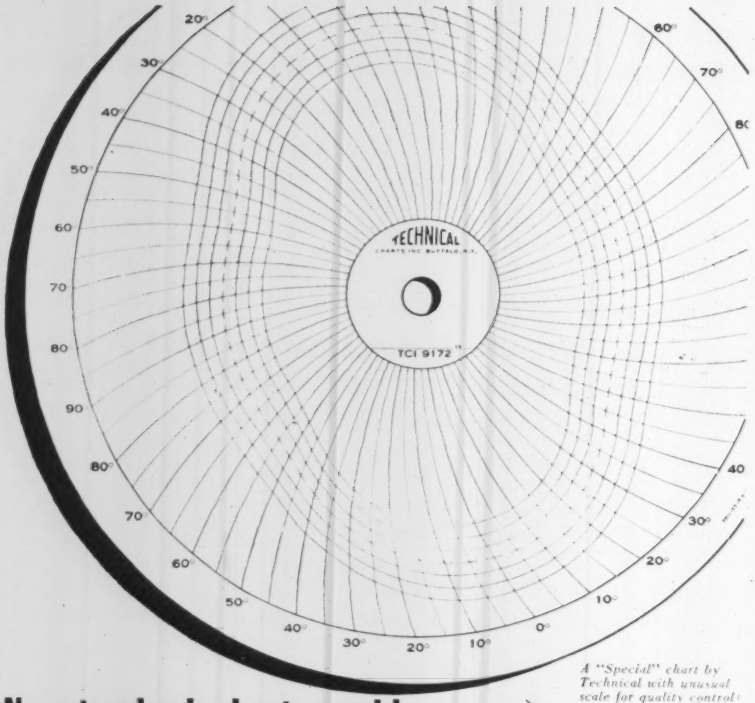
MODEL 150 is a stable, single phase, 150 VA power source of laboratory quality. Output frequency is continuously adjustable between 380 and 2400 cps with stability of 0.1% ±2 cycles. Price $575.

Prices are FOB Boonton, N. J. & subject to change without notice. *Send for product literature.*

Radio Frequency Laboratories, Inc. BOONTON N.J., U.S.A.

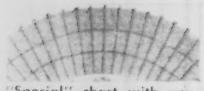
Designers and Manufacturers of Electronic Equipment since 1922

For more information circle **10** on inquiry card.



A "Special" chart by Technical with unusual scale for quality control of critical machining operations.

No standard chart would do the job . . . so TECHNICAL produced these "SPECIALS"!



"Special" chart with unusual grid pattern for quality control of gear teeth.

"Special" chart on transparentized paper for easy reproduction.

Ask Technical to prepare your charts for instruments of your own design, or recordings under unusual conditions!

The choice of the recording *paper* on which your charts are printed can help to solve a wide range of recording problems. Technical has special papers for direct production of recordings, papers with dimensional stability, others that are heat or electro sensitive . . . and more.

Technical will help you engineer "special" recording charts by consulting with you on size, shape, scale and choice of paper to give you charts to fit your specifications exactly. For some types of charts, Technical is the only firm in America that has the experience and facilities to meet your needs.

Write for catalog.

Serving America's "Blue Chip" Industries

BLUE CHIP ACCEPTANCE

TECHNICAL SALES CORPORATION

16599 Meyers Road — Detroit 35, Mich.

National Representatives for

STAEBLER & BAKER, INC. Clayton, N. Y. — TECHNICAL CHARTS, INC. Buffalo, N. Y.

For more information circle **11** on inquiry card.

LETTERS—CONTINUED

rently using, and the information it contains will be of great value to our Cadets.

Major Seymour Shwiller
US Air Force Academy, Colo.

Glad to help our airmen!

reader inquiries

Printing on Glass

Pump manufacturer wishes to contact companies that can print lines or small copy on glass tubes. A-358

Electrolytic Ampere-Hour Meters

Consultant seeks sources for ampere-hour meters which use electrolytic techniques, such as hydrogen type, or similar to Siemens-Schuckert type. A-359

Hydrogen Analyzer

Research professor at polytechnic institute wants to find company that advertised a small radiation absorption meter (with a small built-in radiation source) which measures hydrogen content in material being tested. A-360

Liquid Level Controller

Consulting engineer seeks liquid level controller (proportional type) to control flow into tank of filling machine. Sensing element must be small and sterilizable for milk. Other liquids will range from water-base solutions to oils. A-361

Heat Conductivity Equipment

Engineer in physical lab of large semi-conductor manufacturing company seeks equipment to measure thermal conductivity of ceramic wafers of 0.3 in sq and about 10 mils thick. Materials range from low-conductivity glass to high-conductivity beryllia with greatest interest presently being on alumina. A-362

Conductivity Controller

Manufacturer of glass-washing apparatus seeks inexpensive instrumentation for controlling conductivity of rinse water. A-363

Phase-sensitive Detectors

Engineer seeks apparatus to measure conductance with greater accuracy than with presently available equipment. Feels that phase-sensitive detectors, with accuracy in 0-to-5-degree region, which would separate the resistive component from the capacity of the impedance, would be suitable. A-364

Inside ESC: Number One

RESEARCH KEEPS ESC FIRST

in custom-built delay lines!

From the research laboratories of ESC come pathfinding prototypes that keep ESC first in custom-built delay lines. As America's largest producer of delay lines, ESC has constantly assumed leadership in the vital area of research and development, creating delay lines that have met the most stringent requirements of military and commercial applications.

But there is more to ESC leadership. Its production and quality control facilities are unequalled in the field. ESC submits complete and definitive laboratory reports with all custom-built prototypes which include submitted electrical requirements, photo-oscillograms, the test equipment used, and an evaluation of the electrical characteristics of the prototype.

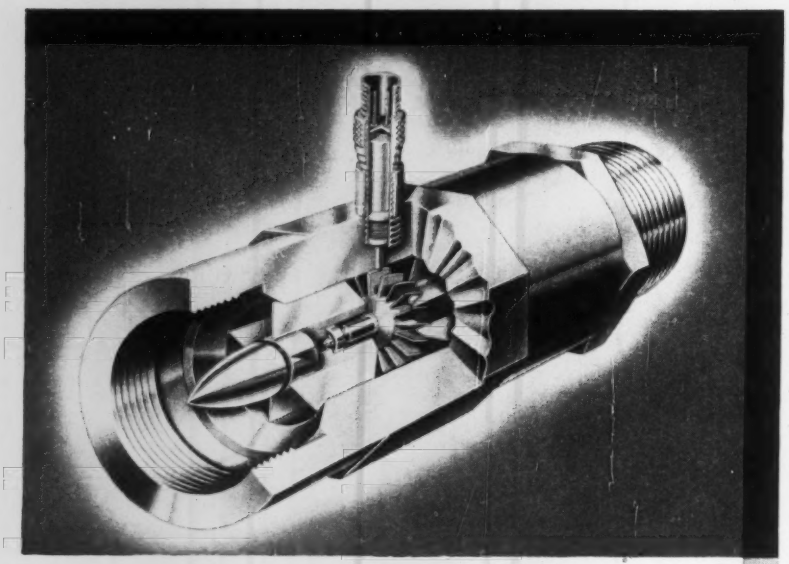
WRITE TODAY FOR COMPLETE TECHNICAL DATA.

exceptional employment opportunities for engineers experienced in computer components... excellent profit-sharing plan.

ESC CORPORATION 534 Bergen Boulevard, Palisades Park, New Jersey

Distributed constant delay lines • Lumped-constant delay lines • Variable delay networks • Continuously variable delay lines • Pushbutton decade delay lines • Shift registers • Pulse transformers • Medium and low-power transformers • Filters of all types • Pulse-forming networks • Miniature plug-in encapsulated circuit assemblies

For more information circle **12** on inquiry card.



★ Meticulously calibrated to insure 1/2% accuracy
★ Easily disassembled for cleaning
★ High frequency output — 120 to 1200 cps
★ High transient frequency response
★ Unharmed by reverse flow

new cox turbine flowmeter

For over 46 years the name "Cox Instruments" has been synonymous with *precision* flow measurement. Such outstanding equipment as Cox Variable-Area Flowmeters and Cox Calibrating Stands have helped make it possible for industry to establish realistic standards for accuracy and reliability in flow measurement.

And now . . . the Cox *Turbine* Flowmeter joins this list of truly precision products. Developed to meet the exacting needs of modern instrumentation systems, it has received the acclaim of initial users throughout industry.

We welcome the opportunity to tell you more about the complete line of Cox Turbine Flowmeters. Write to *Cox Instruments Division, George L. Nankervis Company, 15200 Fullerton Avenue, Detroit 27, Michigan.*

A new technical bulletin describes the complete line of cox turbine flowmeters. Ask for bulletin no. 1300a.

COX INSTRUMENTS

Precision Instruments Since 1912

GLN-1259

For more information circle **13** on inquiry card.

INQUIRIES—CONTINUED

Magnetostrictive Pressure Transducer

Project engineer of research institute seeks pressure transducer operating on magnetostriction principle to measure both slow and fast transients in temperature ranges from 0 to 300°C, and high and low pressure ranges. A-365

Company Address

Research engineer seeks address of *Travis Instruments, Inc.*, manufacturers of pressure pickups. A-366

Punching, Reading, and Feeding Mechanisms

Engineer in data-handling division of large instrument manufacturer wishes to purchase mechanisms for paper-card punching, reading and feeding. A-367

Special Data Logger

Senior engineer in utilities company seeks device which will periodically and automatically read wattmeters, voltmeters and ammeters and make a punched record on tape or card. Device must be inexpensive ($1000 to $1500) as installations are required at 125 stations and substations (both attended and unattended). Number of readings varies from 2 to 171; frequency of readings from hourly to monthly. A-368

Fast Temperature Recorder

Graduate student needs recorder for temperature sensed by thermistor with millisecond response. A-369

Air Bearings

Product engineer of large electrical manufacturing company seeks information on "air bearings" for the suspension of light mechanisms. A-370

Integrating Motors

Consulting engineer seeks American manufacturers of integrating motors similar to product made in England by Electro Methods Ltd. for the integration of minute voltages versus time. A-372

Miniaturized Instrumentation For Dental Office

Dentist, who is an ex-engineer, is interested in obtaining information on electromechanical methods of weighing, volumetric measurement, conveying and mixing, etc. which might be miniaturized for application in a dental office. A-373

Circle **14** on inquiry card. ⟶

This is a direct descendant of the first continuously adjustable autotransformer, commercially developed and manufactured by General Radio Company in 1933.

Carefully designed, conservatively rated, and painstakingly manufactured, with Duratrak brush-contact surface . . .

this is the* 1,000,000th Variac®

* Additional thousands of special VARIACS have been designed for unusual applications

here's how to specify

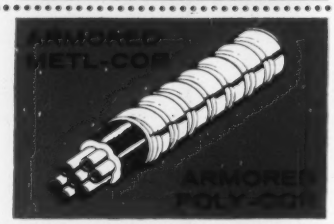
DEKORON INSTRUMENT HARNESS

to fit your requirements exactly

ALUMINUM OR COPPER / POLYETHYLENE OR NYLON + plastic sheath =

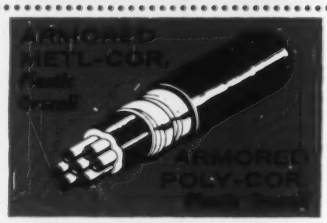
FOR CORROSION RESISTANCE

DEKORON METL-COR / DEKORON POLY-COR + steel armor =



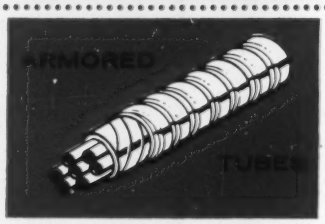
FOR IMPACT AND CORROSION RESISTANCE

ARMORED METL-COR / ARMORED POLY-COR + plastic sheath =



FOR IMPACT AND MAXIMUM CORROSION RESISTANCE

ALUMINUM OR COPPER / POLYETHYLENE OR NYLON + insulating tape + steel armor =



FOR IMPACT RESISTANCE IN DRY LOCATIONS

ARMORED TUBES + plastic sheath =

FOR CORROSION AND IMPACT RESISTANCE

No matter what your special environmental requirements for instrument tubing may be—no matter how stringent for corrosion, impact or fire resistance—there's a type of Dekoron instrument line harness to *satisfy them exactly*. In most cases you can get *delivery from stock*. And *all* Dekoron products have three things in common: Highest quality materials and construction . . . lowest possible installation cost . . . longest life of any instrument line harness. That's *Dekoron—America's Premier Instrument Tubing Line.*

AA-8354

Dekoron® products

QUALITY • RESEARCH • SERVICE

SAMUEL MOORE & COMPANY

DEKORON PRODUCTS DIVISION • MANTUA, OHIO

For more information circle **15** on inquiry card.

Scientific instruments and apparatus sales in 1958 were down 5% below 1957, says SAMA, but 8% increase is expected in 1959.

Commercial Discount Corp. is creating a new division to purchase industry receivables (accounts receivable) in 10 Midwest industries because manufacturers, being paid slowly by their customers, need financing. The industries include electronics and scientific instruments.

Today's $7 billion R&D market should hit $12.5 billion by 1962, says Ken Andersen of SAMA.

210 nuclear reactors were in operation or under construction by end of 1957. AEC predicts that by 1975 US will have 900 atomic power plants, each with a capacity of at least 100,000 kw. This means that by 1975 the nuclear power generated will be same order of magnitude as the entire US generating capacity in 1954 (which was about 100 million kw).

"Conservative estimate" of Capital Radio Engineering Institute of annual dollar volume of nuclear reactor systems in US (excluding turbogenerator plants) by 1960 is $300 million; by 1968 $660 million.

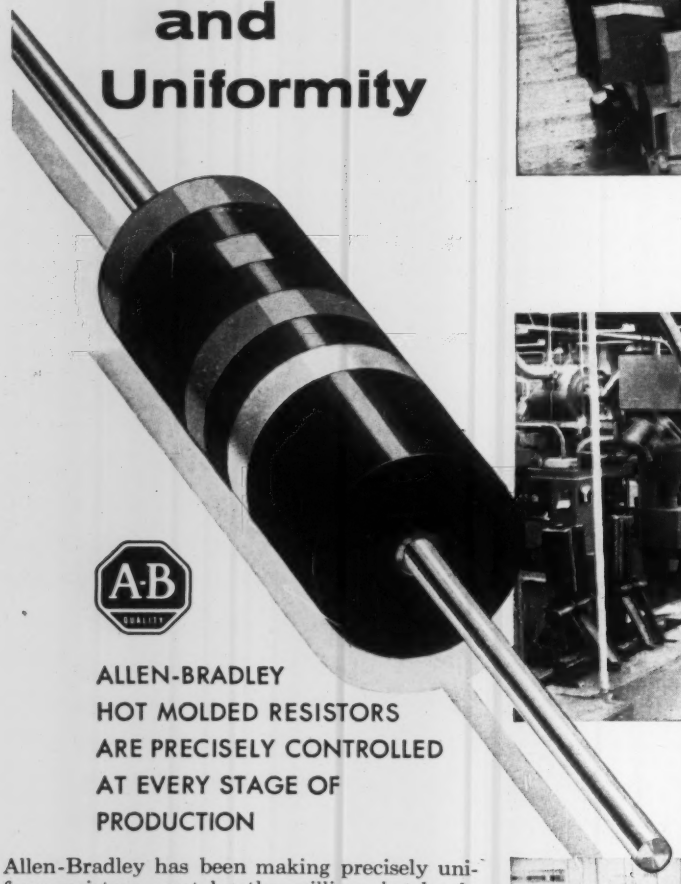
Fortune magazine forecasts a spectacular boom in capital spending during the next two years, saying that even conservative estimates showed that the total capital goods market by the second quarter of 1961 will probably amount to a record $53 billion a year. This would be a 30% increase over present market, and 12% better than 1957. Fortune also reports that man-hour productivity, which is now rising rapidly, will probably continue to go up "by 4% per year for the next eighteen months," and then should level out to its post-war average of 3% a year. At this pace total national production (GNP) will rise from a rate of over $450 billion today to $500 billion in the second quarter of 1960 and to about $525 billion in the second quarter of 1961.

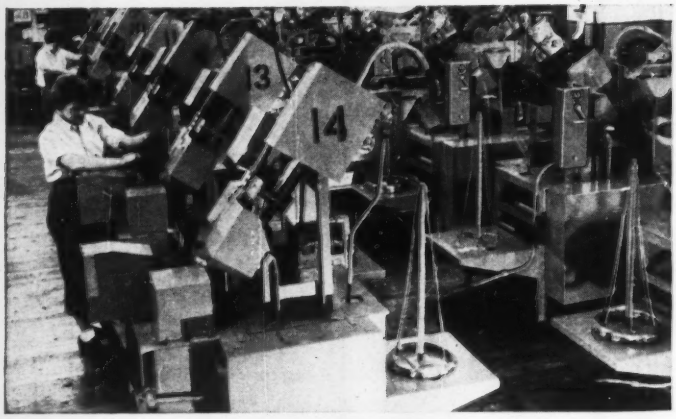
Instrument manufacturers are advised by Dr. Van Zandt Williams (Perkin-Elmer Corp.) to establish manufacturing operations in Europe and to take advantage of the European Common Market.

US is leading supplier of instrumentation to Columbia, but BDSA of Dept. of Commerce reports that US instrumentation exports to Columbia (13-million population) fell sharply in 1957 to $2.6 million, from $5.3 million in 1956. Nearly $2 million of the drop was in control instrumentation. Cause was basic economic factors, including drop in coffee exports. Columbia has one of highest industrial development rates in S. America, with 20% of GNP due to manufacturing.

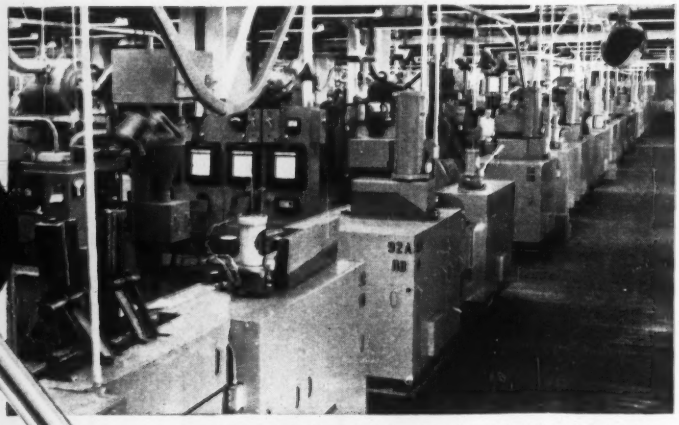
Exports of instruments to Ecuador (4 million population) declined 50% between 1955 and 1957. BSDA reports $1 million instrument market for 1955 and 1956 combined, all imported, with more than 50% from US.

Miracle of Precision and Uniformity

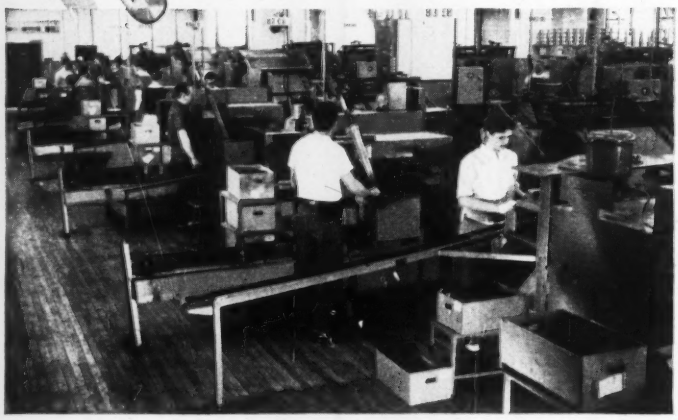




AUTOMATIC HEADING MACHINES form heads on the end of lead wires to make sure they will be solidly anchored in the resistor body. Wire has been previously tinned for easy soldering.



AUTOMATIC MOLDING MACHINES take the resistance powder, insulation powder, and lead wires, and hot mold them under closely controlled high temperature into one integral unit.



AUTOMATIC COLOR CODING MACHINES apply color bands and oven-bake the enamel at high temperatures to assure that the color coding will withstand the maximum operating temperatures of 150°C and all types of cleaning solvents.

ALLEN-BRADLEY HOT MOLDED RESISTORS ARE PRECISELY CONTROLLED AT EVERY STAGE OF PRODUCTION

Allen-Bradley has been making precisely uniform resistors — not by the millions *but by the billions* — over the years. The *exclusive* hot molding process — developed and perfected by Allen-Bradley — uses specially designed automatic machines that incorporate precision control at *every* step of production. Shown here are a few of the special machines that make possible the amazing uniformity — from resistor to resistor, year after year — for which Allen-Bradley composition resistors are famous.

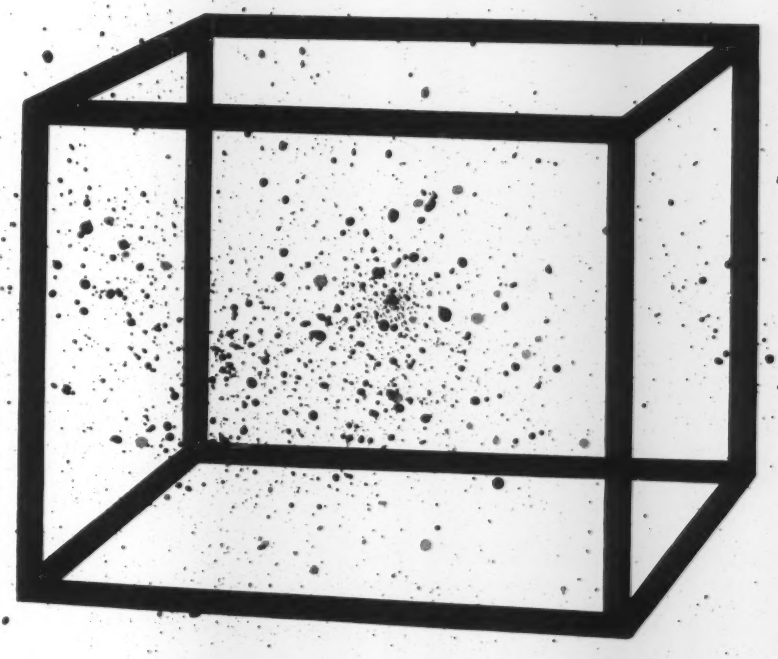
Allen-Bradley Co., 140 W. Greenfield Ave.
Milwaukee 4, Wisconsin

In Canada: Allen-Bradley Canada Ltd.
Galt, Ontario

ALLEN-BRADLEY
QUALITY

Electronic Components

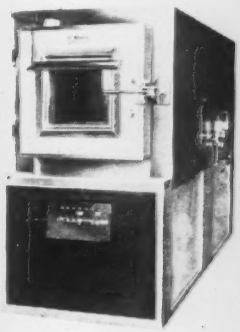
For more information circle **16** on inquiry card.



TENNEY packages any environment

...and delivers on time!

The most extreme field conditions your product will ever meet — duplicated exactly in a compact, precise Tenney environmental testing chamber custom-built for the job! Starting with one of Tenney's extensively-tested chamber prototypes, the right unit can be engineered in a surprisingly short time. In operation, actual environmental conditions are achieved quickly, maintained efficiently throughout the test run, and accurate data is provided for quick, simple evaluation. For literature describing Tenney's prototype chambers, or for recommendations on specific environmental testing problems, write to Tenney Engineering, the world's largest, most experienced creator of environmental testing equipment.



TENNEY ENGINEERING INC. USA

Tenney
ENGINEERING, INC.

1090 SPRINGFIELD ROAD, UNION, N. J.

PLANTS: UNION, N. J. AND BALTIMORE, MD. • THERE IS A TENNEY CHAMBER TO SIMULATE ALTITUDE, HEAT, COLD, HUMIDITY, VACUUM, EXPLOSION, SAND, DUST, FOG, AND MOST OTHER ENVIRONMENTAL CONDITIONS.

For more information circle **17** on inquiry card.

news

Instrument Repair Centers

SCHENECTADY, N. Y.—General Electric Co. has announced establishment of a coast-to-coast network of 11 repair centers. Designed by the Instrument Department they will maintain and repair more than 200 types of

industrial and aircraft instruments made by the Company. They will be operated by the Service Shops Department.

In addition, complete field service will include highly technical engineering when required.

Six of the 11 centers will service both industrial and aircraft instruments; three shops will work on industrial types only, and one shop will service only aircraft instruments.

Fluid Controls Institute Holds Fall Meeting

The Fall Meeting of the Fluid Controls Institute, Inc. was held at the Drake Hotel, Chicago, November 24-25, 1958. The meeting was opened with President, Dean E. Madden of A. W. Cash Valve Mfg. Corp., presiding. An interesting program was prepared by the Chairman of the meeting, J. R. Lawler, Jr. of Lawler Automatic Controls, Inc. Reports were received from Membership Committee, Elmer W. Rietz; Treasurer, Paul K. Rogers, Jr.; Business Statistics Committee, Joseph Naab. A panel discussion on the subject of "Research & Development" was held in the morning.

On November 25, reports from the various standing committees on past activities and future plans, the section chairman and the president were received.

The membership of the Fluid Controls Institute, Inc. consists of individuals from prominent manufacturers of automatic regulating valves, control valves, solenoid valves, space heating specialties, steam and gas traps and steam heating pumps.

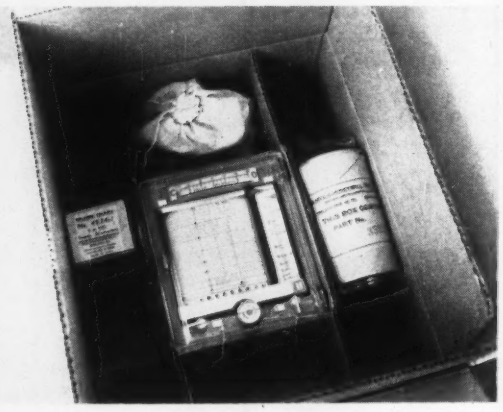
Aerating Cardiac Pump

SAN DIEGO, CALIF.—What do missile computer men do in their spare time? At least one invents heart-lung machines. John McLeod of Convair Astronautics (and editor of your *Simulation Council Newsletter*) has de-

signed the first portable heart-lung machine. Called the MAC Pump (from McLeod Aerating Cardiac), John designed a "breadboard" model with the advice of four doctors from the San Diego Bio-medical Research Institute. The prototype has been used successfully in three animal operations. In one of these a dog was "on the pump" for 50 minutes while his own heart and lungs were completely clamped off.

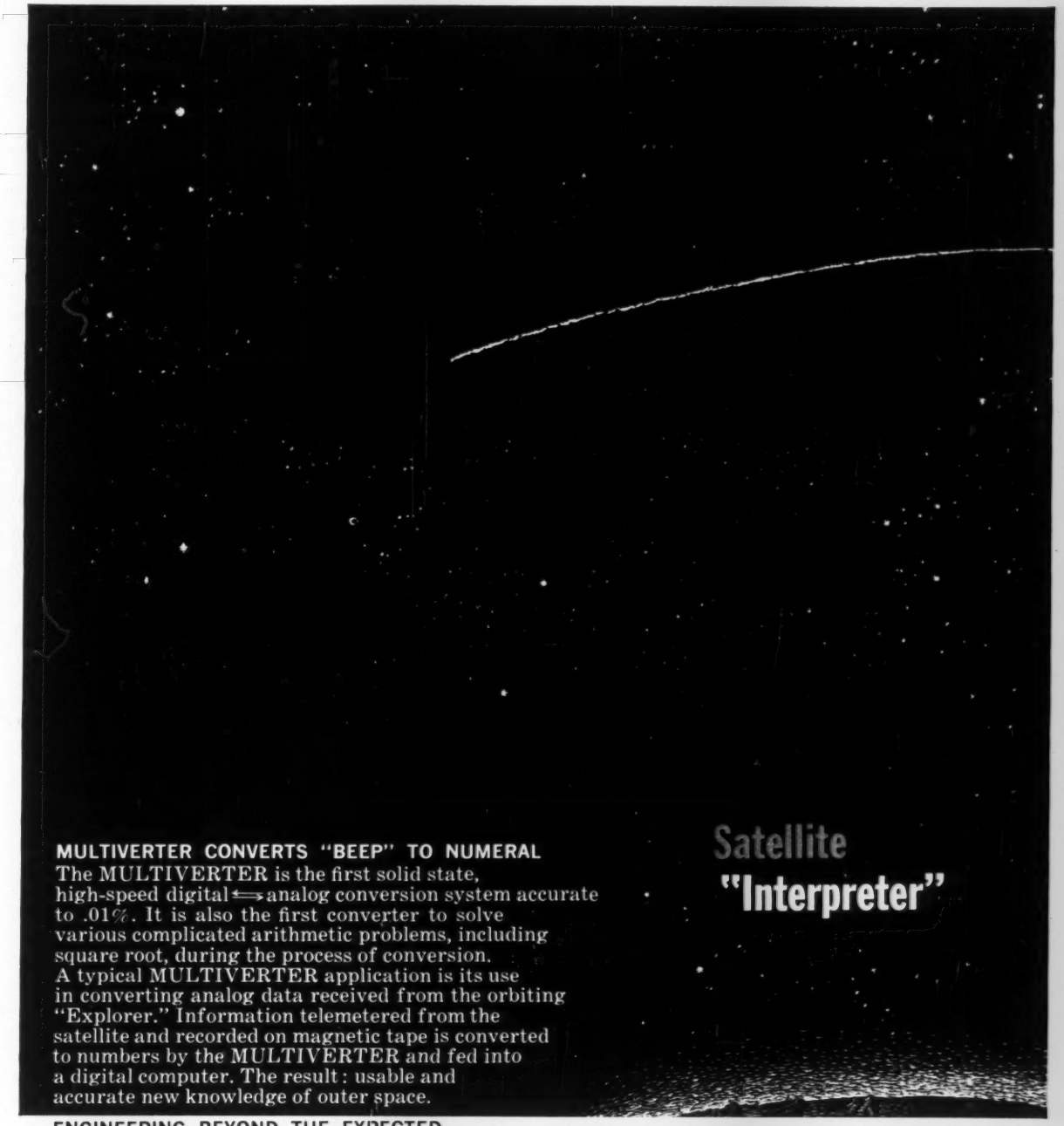
How Instruments are Shipped

PHILADELPHIA, PA.—Brown Instruments Division, of Minneapolis-Honeywell Regulator Company, recently switched to custom-designed corrugated cartons for the packaging and shipping of pneumatic-operating indicat-



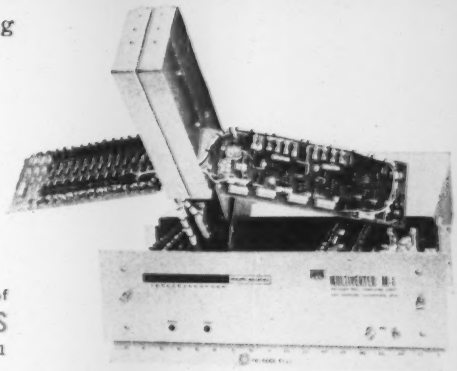
ing, recording and control instruments. One reason was the need to insure customer satisfaction by providing maximum safety for the instruments during shipment. The new corrugated boxes, which are manufactured by Union Bag-Camp Paper Corporation, have enabled reduced packaging costs and lighter shipping weight.

THE BRISTOL COMPANY (Waterbury 20, Conn.) again offers five training courses: Instruments in general; telemeter servicing; advanced telemetering; pneumatic instruments; and self-balancing bridges and potentiometers.



MULTIVERTER CONVERTS "BEEP" TO NUMERAL
The MULTIVERTER is the first solid state, high-speed digital⟺analog conversion system accurate to .01%. It is also the first converter to solve various complicated arithmetic problems, including square root, during the process of conversion. A typical MULTIVERTER application is its use in converting analog data received from the orbiting "Explorer." Information telemetered from the satellite and recorded on magnetic tape is converted to numbers by the MULTIVERTER and fed into a digital computer. The result: usable and accurate new knowledge of outer space.

ENGINEERING BEYOND THE EXPECTED
The need for highly accurate measurement in an accelerating technology called for a solid state converter with an accuracy of .01% and a speed of four microseconds per bit. The MULTIVERTER and related accessories resulted. One immediate application has been the interconnection of Packard Bell's TRICE, the first incremental differential analyzer to operate in real time, with various analog systems. Other applications include Missile Impact Prediction, Coordinate Conversion, Orbit Prediction and Solid State Automatic Checkout Systems.



Packard Bell Computer Corp., a subsidiary of
PACKARD BELL ELECTRONICS
12333 W. Olympic Blvd., Los Angeles 64, Calif., BR 2-2171

For more information circle **18** on inquiry card.

With CECO
Remote Pan & Tilt Head
ONE CLOSED CIRCUIT
TV CAMERA DOES
THE WORK OF SEVERAL

Mounted on the highest tower or crammed into a tiny crevice, your Vidicon TV camera is always at your finger-tip control when you have it mounted on CECO's full circular Pan & Tilt head. Moreover, the operator can manipulate as many cameras as required through a control box located far from the installation.

New "Dialastop" limiting switches on the head permit any degree of presetting within full 360° for both pan and tilt movements.

Made of high tensile strength aluminum alloy with grey crackle finish. Ball and needle bearing construction, micro limit switches, high torque motors, non-slip worm gear drives. Mounts on PRO JR. Remote Tripod or Hi-Hat low mount. Airplane clamp bracket available.

In jobs where camera installations are too inconvenient or dangerous for an operator to remain, be sure to use the new CECO Remote. Write for more information today.

SPECIFICATIONS:

SIZE: 10" x 9". WEIGHT: 14½ lbs. CAPACITY: 20 lbs. MOUNTING: Tripod or base, ceiling, wall or in any desired angle. MOTOR REQUIREMENTS: 110 volt, 60 cycle AC. (DC and other voltage available). CONNECTORS: Cannon, 6 leads, one wire. **PRICE: $400.00**

FRANK C. ZUCKER
CAMERA EQUIPMENT CO., INC.

Dept. 1A, 315 W. 43rd St., N. Y. 36, N. Y. JUdson 6-1420

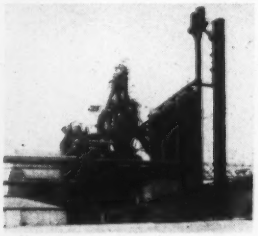
For more information circle **19** on inquiry card.

NEWS—CONTINUED

STROMBERG-CARLSON DIV. of General Dynamics Corp. has taken a subcontract from Bailey Meter Co., prime contractor, to design and manufacture the nuclear instrumentation and safety systems for the fast-neutron-breeder type reactor of the Enrico Fermi Atomic Power Plant now under construction near Detroit.

SIMPSON ELECTRIC's new lab standard calibrator Model 2600 is being shown in picture by Frank Hadrick, sales engineer, (right) to Norm Kathrinus in its application to check calibration and accuracy of various VOM's and VTVM's. The occasion was a recently-held test equipment workshop.

Simpson's Calibrator



Hagan Controls "Patricia"

HAGAN tuyere flow proportioning controls, blower controls, and stove gas/air ratio controls keep "Patricia," the #3 Blast Furnace at Fairless Works of United States Steel Corp., working at maximum efficiency.

STERLINGTON STEAM ELECTRIC STATION, Sterlington, La. has its Daystrom Systems Operational Information System on line, logging computed operational guides. System uses general-purpose digital computer with 2048-word magnetic-core memory. Computer and associated equipment is completely transistorized.

PANELLIT Service Corp. has received a contract to install the entire electronic/pneumatic instrumentation and automation system in Crown Zellerbach Corp.'s new St. Francisville, La., paper mill.

RAY H. MATTINGLEY (P. O. Box 286, Oakhurst, N. J.) has announced plans for the publication of a monthly industrial and engineering magazine *Environment*—encompassing the growing field of environmental testing equipment.

W. & L. E. GURLEY photographed on special cameras 88 star patterns for the new-type planetarium system installed in the Charles Hayden Planetarium at the Museum of Science in Boston. This farthest-advanced system consists of 176 separate projectors, all built into a single instrument.

ELECTRONIC ASSOCIATES will hold their seventh "Advanced Course on Analog Computation" at their Princeton Computation Center February 9 through 20, 1959.

AUTOMATIC CONTROL FOR PROCESS INDUSTRIES is the title of a two-day engineering institute to be held February 11-12, 1959 by the University of Wisconsin Extension Division at Madison, Wis. Lecturers announced include Dave Boyd, Universal Oil Products Co., Henry Stoll, Taylor Instrument Cos., and Dr. Don Eckman, Case Institute. For information write Robert Loetscher, University of Wisconsin, Extension Div., Dept. of Engineering, Madison 6, Wis.

Circle **20** on inquiry card. ⟶

FAST! – *up to 200 cps*

SENSITIVE! – *low as ±2.5 milliwatts*

NEW CLARE Type HGS Mercury-Wetted Contact Relay

IDEALLY SUITED TO HIGH SPEED SWITCHING DEVICES

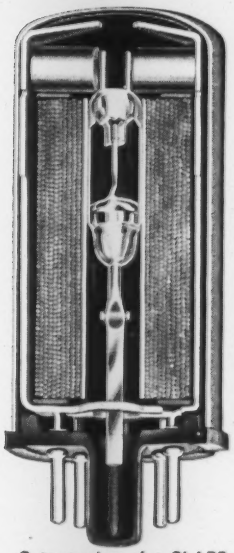
The Type HGS Relay is a new variety of CLARE Mercury-Wetted Contact Relay, developed to meet the needs of modern design engineers for faster and more sensitive relays. The HGS Relay is especially suited to all types of high-speed switching devices, over-voltage and overload protection devices and high-power chopper applications.

Operating speeds may be up to 200 cps or more. Sensitivity may be as low as ±2.5 milliwatts for a bi-stable adjustment, as low as 5 milliwatts for a single-side-stable adjustment. Contact rating is 2 amperes, 500 volts, with a limit of 100 volt-amperes.

Supplements Clare HG and HGP Relays

The new CLARE Type HGS Relay will not supplant the revolutionary Types HG and HGP. It will supplement these relays in applications which require higher speed or greater sensitivity.

The Clare Type HGS is similar to the Types HG and HGP except that the HGS is always biased with permanent magnets. These are adjusted to single-side-stable or bi-stable operation.



Cutaway view of a CLARE Type HGS Relay. Mercury-wetted contact switch is sealed in glass and surrounded by the operating coil. Biasing magnets are attached to the upper ends of the side plates.

ELECTRICAL FEATURES

Long Life: Over one billion operations at rated load.

Operation Speed: Up to 200 cps with consistent performance. Higher if some variation is tolerable.

High Sensitivity: 5 milliwatts for single-side-stable adjustment; ±2.5 milliwatts for bi-stable adjustments.

Stable Operation: 0.1 millisecond maximum operating time variation.

Freedom from Chatter: Absolutely NO CONTACT BOUNCE.

Low, Stable Contact Resistance: Initial contact resistance, 25 to 50 milliohms, does not vary by more than 1 or 2 milliohms during life of contacts.

Low Ratio Coil Inductance: Low inductance-to-resistance ratio of coil suits relay well for transistor-drive applications.

MECHANICAL FEATURES

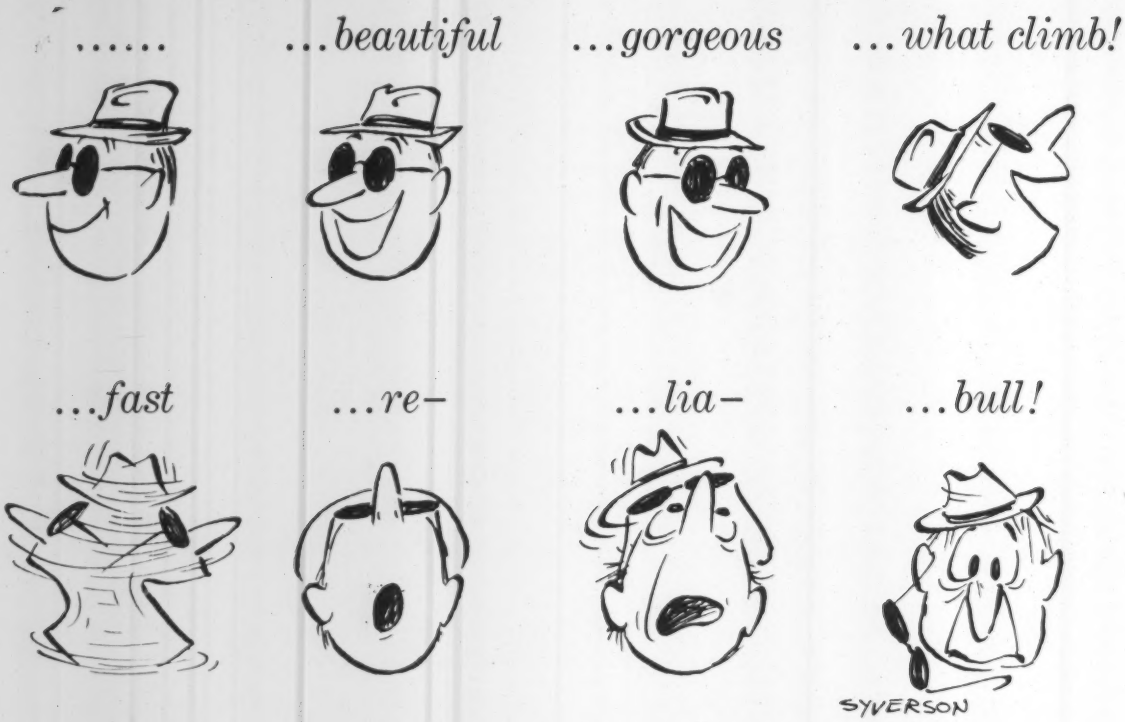
Conveniences: Small, light-weight; plugs in like vacuum tube; completely protected from atmospheric conditions; contacts cannot wear, weld, stick or chatter; tamper-proof; requires no maintenance.

Durability: Easily withstands normal handling and transportation shocks.

Send for CLARE Sales Engineering Bulletin No. 125 for complete information on the new Type HGS Relay. Bulletins 120 and 122 describe HG and HGP Relays. Write: C. P. Clare & Co., 3101 Pratt Blvd., Chicago 45, Illinois. In Canada: C. P. Clare Canada Ltd., 2700 Jane Street, Toronto 15. Cable Address: CLARELAY.

CLARE RELAYS

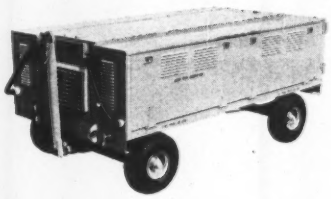
FIRST in the industrial field



High-flying, high-cost investments deserve protection. The best policy is pre-flight testing that checks out vital avionic systems on the ground... insures expensive ventures into space. Look to INET for the precise electrical power you can wheel right out on the flight line... in a single, custom-made package.

NEXT TIME...LOOK TO INET FOR PROVEN RELIABILITY

This INET unit was tailor-made for one of the latest Air Force Fighter-Interceptors. In seconds it brings to life all the avionic systems the plane will carry aloft. The unit provides eight power outputs for separately generated 1,600-cycle, 400-cycle, and DC power at closely regulated voltages for power supply, instrumentation checkout, and equipment testing.



▶ Engineers desiring a special reprint of the above cartoon should write to: "FLAME-OUT" c/o Inet Division of Leach.

INET DIVISION LEACH CORPORATION

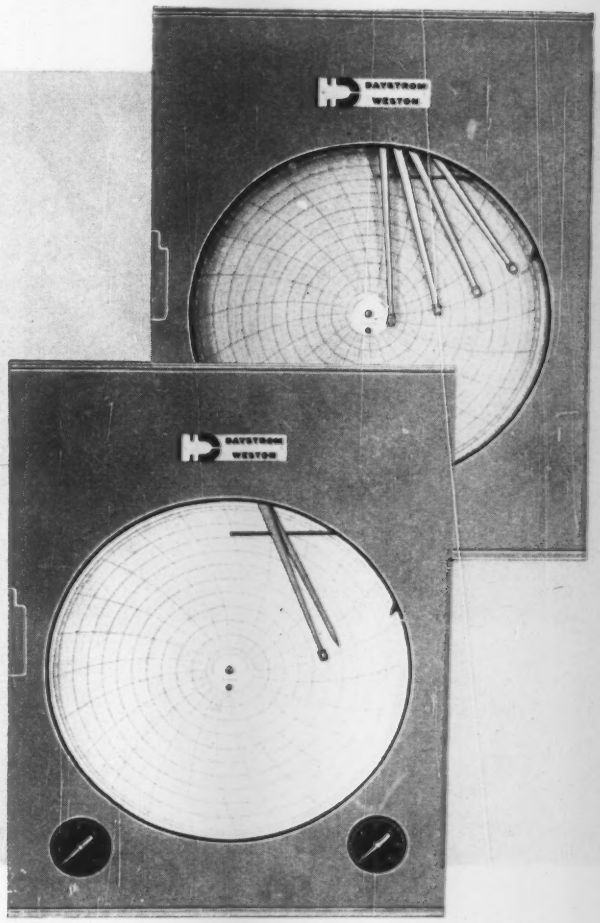
18435 SUSANA ROAD, COMPTON, CALIFORNIA

DISTRICT OFFICES AND FIELD REPRESENTATIVES IN PRINCIPAL CITIES OF U.S. AND CANADA
EXPORT: LEACH CORPORATION, INTERNATIONAL DIVISION

For more information circle **21** on inquiry card.

FILLED SYSTEM TEMPERATURE RECORDERS AND RECORDER-CONTROLLERS

Daystrom-Weston designs *New* VERSATILITY into these UNITIZED* temperature instruments



This new line of recorders and recorder-controllers covers the complete range of filled system instruments. Charts and ranges are available as low as −100° F. and as high as 1000° F. The series includes *Model 7811:* single pen recorder . . . *Model 7812:* multi-pen recorder *Model 7815:* single pen recorder-controller . . . *Model 7816:* two pen, two control unit . . . *Model 7817:* two pen, single control unit.

All models come in dust- and moisture-proof cases for universal mounting. Cases and internals are unusually clean in design, and provide easy accessibility. Pens have large capacities, rugged suspensions and automatic lifters. In addition, the series offers these important features:

- Interchangeable thermal systems — liquid-, vapor-, gas-, or mercury-filled.
- 12-inch charts, with 4.75-inch pen travel.
- Universal pneumatic controller may be used as a proportional . . . on-off . . . or differential gap controller.
- Proportional controller is available with reset — or reset and derivatives.
- Proportional band adjustability from 2 to 300%.
- Reset and derivative valves are adjustable from 0.02 to 5 minutes.
- Control setting and manual reset are simplified and easily accessible.

Circulars M-15-A and M-18-A contain full specifications. Contact your local Weston representative, or write to Weston Instruments, Division of Daystrom, Inc., Newark 12, N. J. *In Canada: Daystrom Ltd., 840 Caledonia Rd., Toronto 10, Ont. Export: Daystrom Int'l., 100 Empire St., Newark 12, N. J.*

***UNITIZATION:** the grouping of related components—in Daystrom-Weston Industrial Instruments — in the simplest, most serviceable, most efficient manner.

DAYSTROM-WESTON

A DAYSTROM UNIT

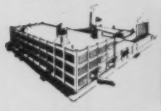
Industrial Instruments

For more information circle **22** on inquiry card.

DIALCO's expanded line of sub-miniature lights conform to all applicable Mil Specs. Use T-1¾ midget incandescent lamps—1.3 to 28 V. Spring mounted *Lens-with-Message* is readily positioned *after* installation ... Mount from *back* of panel in 15/32" clearance hole; or from *front* of panel in 17/32" hole ... 7 lens colors ... Shown approx. actual size (top to bottom): No. 134-3830-375-6 ... No. 101-3830-951 ... No. 101-5030-951 ... No. 109-3830-111 ... No. 111-3830-111 ... No. 107-1930-951.

Complete details in Brochures L-156 A and L-157.

SAMPLES ON REQUEST—AT ONCE—NO CHARGE



Foremost Manufacturer of Pilot Lights

DIALIGHT
CORPORATION

42 STEWART AVE., BROOKLYN 37, N. Y. • HYacinth 7-7600

DIALIGHT CORP., 42 Stewart Ave., Brooklyn 37, N. Y.
☐ Send brochures on Sub-miniatures ☐ Selection Brochure ☐ Pilot Light Catalogues
Name ..... Position .....
Company .....
Address .....

For more information circle **23** on inquiry card.

stock report

Any further information concerning any of the following issues may be obtained from the Research Department, Bache & Co., 36 Wall Street, New York 5, N. Y.

American Stock Exchange:

AMERICAN STOCK EXCHANGE
Price Range 1958 thru 12/17/58

	HIGH	LOW	PRICE AS OF 12/17
American Meter	39 1/2	27 5/8	38 3/4
Arc Equipment	23 1/2	13 3/4	20¾-20¾ (1
Barry Controls "B"	17	4 3/8	12 5/8
Belock Instruments	13	7 3/8	11 3/8
Benrus Watch	7 1/2	4 7/8	6 5/8
Breeze Corp.	7 1/8	5 1/8	6 1/4
Clark Controller	24	14 7/8	19 5/8
Clarostat Mfg.	5 1/2	2 7/8	4 7/8
Clary Corp.	7	2 7/8	6 3/8
DuMont Laboratories	8 1/4	5	8 1/8
Dynamics Corp. of America	5 1/2	2 7/8	5
Electronics Corp. of America	16 1/4	6 3/8	15 7/8
El-Tronics	3 3/4	5/8	1 1/8
Fairchild Camera & Instrument	34 3/4	29 1/2	55
Globe-Union	20 1/4	14 5/8	19 3/8
Hazeltine Corp.	58	30 1/2	56
International Resistance	9 1/2	3 3/4	9 1/8
Lear, Inc.	10 1/4	4 1/4	9 7/8
National Research	17 3/8	12 7/8	15 1/2
Neptune Meter	35	19 1/2	34 7/8
New Haven Clock	3 1/4	7/8	1 5/8
Nuclear Corp. of America	2 1/8	7/8	1 7/8
Pneumatic Scale	36 3/4	18 1/2	32 1/2
Servo Corp. of America	21	3 3/4	19 1/8
Servomechanisms	11 3/4	6 5/8	10 1/4
Wallace & Tiernan	40 3/4	24	37 1/2
Waltham Prec. Instrument Co.	1 1/2	13/16	1

1) Not Traded - Bid and Asked

New York Stock Exchange:

Price Range for 1958 Through 12/17/58

	HIGH	LOW	Price as of 12/17/58
ACF Industries	49 5/8	37 1/8	47
Aeroquip Corp.	25 3/4	16 7/8	25 1/4
Allis Chalmers	29 3/4	22 1/8	27 7/8
American Chain & Cable	51	39 1/2	48
American Machine & Foundry	59 3/4	32 1/4	54 1/8
American Machine & Metals	70	47 1/2	66 1/4
American Optical	40 5/8	34 3/4	38 5/8
American Tel. & Tel.	225	167 7/8	223
Beckman Instruments	99 1/4	28 1/8	96 1/4
Bell & Howell	94 7/8	42	88 3/8
Bendix Aviation	74 1/2	44 1/2	71 1/2
Boeing Airplane	68 1/8	34 1/8	47 1/8
Ballard	18 1/2	10	15 1/2
Bulova Watch	26 3/4	9 3/4	24
Burroughs	43 3/8	27 5/8	42 1/8
Carborundum	41 3/4	30 7/8	41
Cincinnati Milling Machine	44 1/2	27	39 1/2
Clevite	25	15 3/4	23 3/4
Columbia Broadcasting "A"	42 1/2	24 1/2	37
Consolidated Electrodynamics	47 1/2	27 7/8	45 1/4
Consolidated Electronics	44¾/4	19 1/2	43 5/8
Cornell Dubilier	24 7/8	12 3/4	23 7/8
Corning Glass	99	74 5/8	90
Curtiss-Wright	31 1/2	20 1/8	26 1/4
Cutler-Hammer	63 1/2	40 1/2	58 3/4
Davstrom	39 1/4	30	37
Douglas Aircraft	74 7/8	54 1/2	67 3/4
Eastman Kodak	244 1/2	97 1/8	198
Eaton Manufacturing	59	36 1/2	56 3/4
Electric Auto Lite	39	25	36 1/8
Elgin Watch	21 3/8	6 3/4	20 3/4
Emerson Electric	56 1/2	29	52
Food Machinery & Chemical	46	35 1/4	46
Gamewell	42 3/4	20 1/2	38 3/4
Garrett	45 1/2	27	43 1/4
General Controls	28 3/4	14	26 1/8
General Dynamics	67 5/8	55	61 1/2
General Electric	73 1/8	57	72 5/8
General Instrument	21 5/8	4 5/8	21 5/8
General Mills	69	60 1/4	67 3/4
General Precision Equipment	42	27	34
General Railway Signal	39 7/8	21 1/8	38 1/8
General Telephone	63	40 3/8	61 7/8
General Time	27 1/4	20 5/8	26 1/2
General Tire & Rubber	50 1/4	22 1/4	40 1/4
International Business Machine	496	300	496
International Tel. & Tel.	65 3/8	29 1/4	64 3/4
ITE Circuit Breaker	42 3/8	34 3/4	35 5/8
Litton Industries	90 3/4	36 7/8	64 5/8
Lockheed Aircraft	69 1/8	38 3/8	65 3/4
Magnavox	60 1/2	30 1/4	53 3/4
Mallory	59 7/8	23 5/8	38
Minneapolis-Honeywell	120	76	119
Minneapolis Mining & Mfg.	110	73 1/2	106 3/4
Motorola	60 1/4	35	58 3/4
National Acme	59 1/4	43 7/8	52 3/4

Continued on page 26

FOR MORE INFORMATION ON ANY OF THE PRODUCTS REPORTED OR ADVERTISED IN THIS ISSUE, CIRCLE THE ITEM NUMBER ON THE INQUIRY CARD ON PAGE 161. IF THE CARD HAS ALREADY BEEN USED, WRITE NUMBER; DATE OF ISSUE; YOUR NAME, ADDRESS, COMPANY, PRODUCTS MANUFACTURED ON A POSTAL CARD. MAIL C/O READER SERVICE.

Engineered WEIGHING SYSTEM NEWS

EVALUATE THE PRACTICAL ACCURACY OF YOUR ENTIRE TANK WEIGHING SYSTEM

DO NOT BE MISLED BY ACCURACY CLAIMS MADE FOR A SINGLE COMPONENT

Has it occurred to you that a glib sales claim of .1% accuracy in a weighing component is no guarantee whatever that the system will operate with such accuracy under normal service conditions? In fact, every instrument engineer knows that consistent accuracies of .1% under normal operating conditions are a practical impossibility.

Under controlled laboratory conditions consistent .1% accuracies are barely possible . . . but in the field . . . practically never!

Emery Engineered Weighing Systems are designed for the needs of each particular job. It is through this individual engineering that we are able to achieve a maximum accuracy which is impossible when components are lifted from stock.

In selecting your tank weighing system, investigate thoroughly all sales claims of fantastic component accuracy. Evaluate the practical accuracy of the entire system. Do not be misled by the accuracy claims that are made for a single component. After your evaluation . . . buy the system with the best practical approach to your weighing problem . . . the Engineered Weighing System by Emery.

When writing, refer to Item 1001.

INSTRUMENT COMPANIES RECOGNIZE DESIRABILITY OF STRONGER SIGNAL

Standardization on an electrical operating signal in the range of 10 to 50 millivolts for electrical instruments indicates the trend of today's thinking as evidenced by the instrument industry.

Should this standardization program become effective tank weighing system users may take note that the Engineered Weighing System by Emery can team up immediately with such instrumentation without the use of additional equipment.

When writing, refer to Item 1002.

NEW WAY-PAC BULLETIN IS NOW AVAILABLE

Our new Bulletin 582 covering the WAY-PAC line of engineered weighing systems is now being distributed throughout the industry. If you haven't done so yet, send for your copy right away.

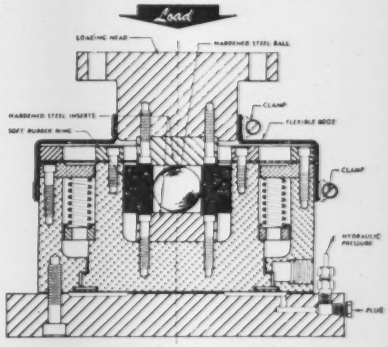
When writing, refer to Item 1005.

TANK EXPANSION DAMAGE PREVENTED WITH EMERY ENGINEERED WEIGHING SYSTEMS

The unique and exclusive Emery Rolling Ball Head built into the Emery Load Cells is your guarantee that no damage to the weighing system will result from inevitable tank expansion and contraction.

The Rolling Ball Head is a clever device which allows side motion of tanks due to expansion and contraction without sacrificing any of the accuracy of the Emery Engineered Weighing System. A system which does not take into consideration this expansion and contraction is not properly designed.

When writing, refer to Item 1003.



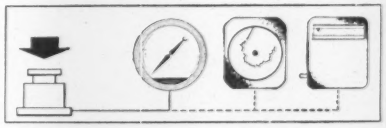
Key to protection of Emery Weighing Systems from side load damage is the unique design of the rolling ball head . . . an Emery exclusive.

EXPLOSION-PROOF FEATURE VALUABLE IN MANY CHEMICAL TANK INSTALLATIONS

The importance of explosion-proof equipment in many chemical installations cannot be minimized. There is no room for deliberation . . . no opportunity for experimenting. Either the equipment is explosion-proof or not.

Emery Engineered Weighing Systems can be supplied to operate completely on either the hydraulic or pneumatic principle of load measurement. However, when electrical instrumentation is specified, we will supply this instrumentation in explosion-proof cases which have underwriter approval. An Emery Engineered Weighing System is available to provide positive explosion-proof protection in practically every chemical application. Inquire for detailed information.

When writing, refer to item 1004.



Your Emery Weighing System can be completely hydraulic or pneumatic or it can contain electrical instrumentation in explosion-proof cases for positive protection.

The A. H. Emery Co., New Canaan, Conn.

I am interested in the following:

Item 1001 ☐ Item 1003 ☐ Item 1005 ☐

Item 1002 ☐ Item 1004 ☐

Seeing Representative ☐

Name .....

Title .....

Address .....

City ..... State .....

1000

THE A. H. EMERY COMPANY

New Canaan, Conn.

Engineered WEIGHING SYSTEMS

For more information circle **24** on inquiry card.

PHILADELPHIA
THERMAL CONTROLS AND THERMOMETERS
Specify!
THE BEST!
A half century of experience is back of every instrument we make. You get assured accuracy and long dependable performance when you specify "Philadelphia." Our specialized staff will be glad to discuss your problem in our field.
SEND FOR CATALOG 110
Since 1905
PHILADELPHIA THERMOMETER CO.
4401 N. Sixth St. • Philadelphia 40, Pa.

For more information circle **25** on inquiry card.

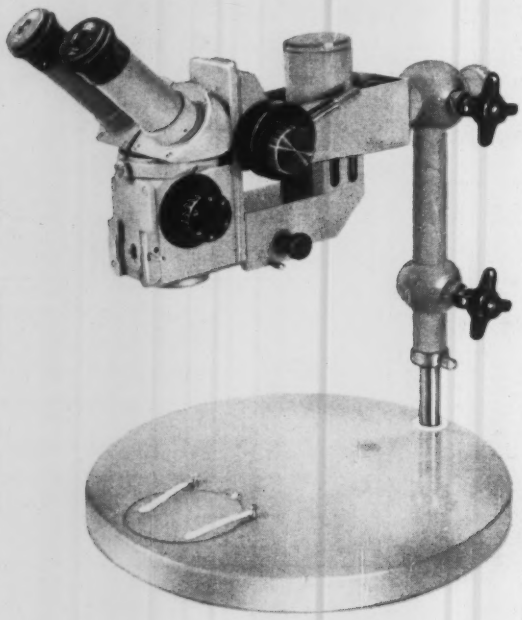
STOCK REPORT

New York Stock Exchange: *Continued from page 24*

Page 2.	HIGH	LOW	PRICE AS OF 12/17/58
National Cash Register	80 3/8	50 1/2	79 1/8
North American Aviation	44 3/8	25 5/8	44
Northrop Aircraft	37 1/2	22 1/8	35 3/4
Otis Elevator	74	40 1/4	70 3/4
Philco Corp.	26 3/8	12 3/8	23 7/8
Radio Corp. of America	47 3/8	30 1/4	45 5/8
Raytheon Mfg.	69	21 1/2	67 5/8
Reliance Electric	50 1/4	31	46 1/2
Rheem Mfg.	19 1/2	10 1/2	18 3/4
Robertshaw-Fulton	33 3/4	22 1/4	32 3/8
Royal McBee	25 1/4	16	24 7/8
Sangamo Electric	26 3/4	25	26
Sperry Rand	25 3/8	17 1/4	24 5/8
Square D	30 3/4	20 1/8	30 1/2
Standard Coil Products	17 5/8	6	15 1/8
Starrett (L.S.)	74 3/4	57	66
Stevart-Warner	45 1/4	29	42 7/8
Sylvania Electric	61 1/2	31 1/2	60
Telautograph	9 7/8	3 3/4	9 1/4
Texas Instruments	86	26 3/4	73 3/8
Thompson Ramo-Wooldridge	73	41 3/8	71 1/4
Tung-Sol Electric	36 1/2	23 1/4	36
Underwood Corp.	23 1/8	12 7/8	21 7/8
Union Carbide Corp.	125 1/4	83 7/8	125
United Shoe Machinery	47 5/8	32	45 1/2
Western Union	34 3/4	15	33 3/4
Westinghouse Air Brake	29 3/4	17 7/8	27 1/2
Westinghouse Electric	71 3/4	55 1/2	69 1/4
Worthington Corp.	73 7/8	45 1/4	73 7/8

Over-The-Counter

OVER-the-COUNTER	QUOTATION AS OF 12/17/58 BID	ASKED
Aerovox Corp.	6 1/2	6 7/8
Aircraft Radio Corp.	26 1/2	27 1/4
Argus Corp.	28 3/4	29 1/4
Eitel-McCullough	29	30
Electronics Associates	46 1/2	48
Erie Resistor Corp.	8 3/4	9 1/4
Fisher Governor Company	15 1/8	15 3/4
Foxboro Company	49	51
G.M.Giannini	26 3/4	28
Industro Transistor	2 5/8	3 1/8
Liquidometer Corp.	6 1/2	7 1/4
W.L.Maxson	10 5/8	11 1/4
Penn Controls, Inc.	28 3/4	29 3/4
Speer Carbon, Inc.	30 1/4	31 3/4
Sprague Electric	42 1/2	43 3/4
Taylor Instruments	35 3/4	37
Telecomputing Corp.	8 5/8	9 1/8
Topp Industries	13 5/8	14 1/8
Varian Associates	36 5/8	37
Vitro Corp. of America	14 3/4	16 1/8



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MADE IN WEST GERMANY

A new, modern stereoscopic binocular microscope eminently suited for industrial inspections and examinations.

Intense illumination parallel with line of vision. Erect, plastic image even in deep cavities.

Free working distance of 8 inches. Magnification changing device provides rapid succession of 6.3x, 10x, 16x, 25x and 40x magnifications.

Write for free detailed literature.

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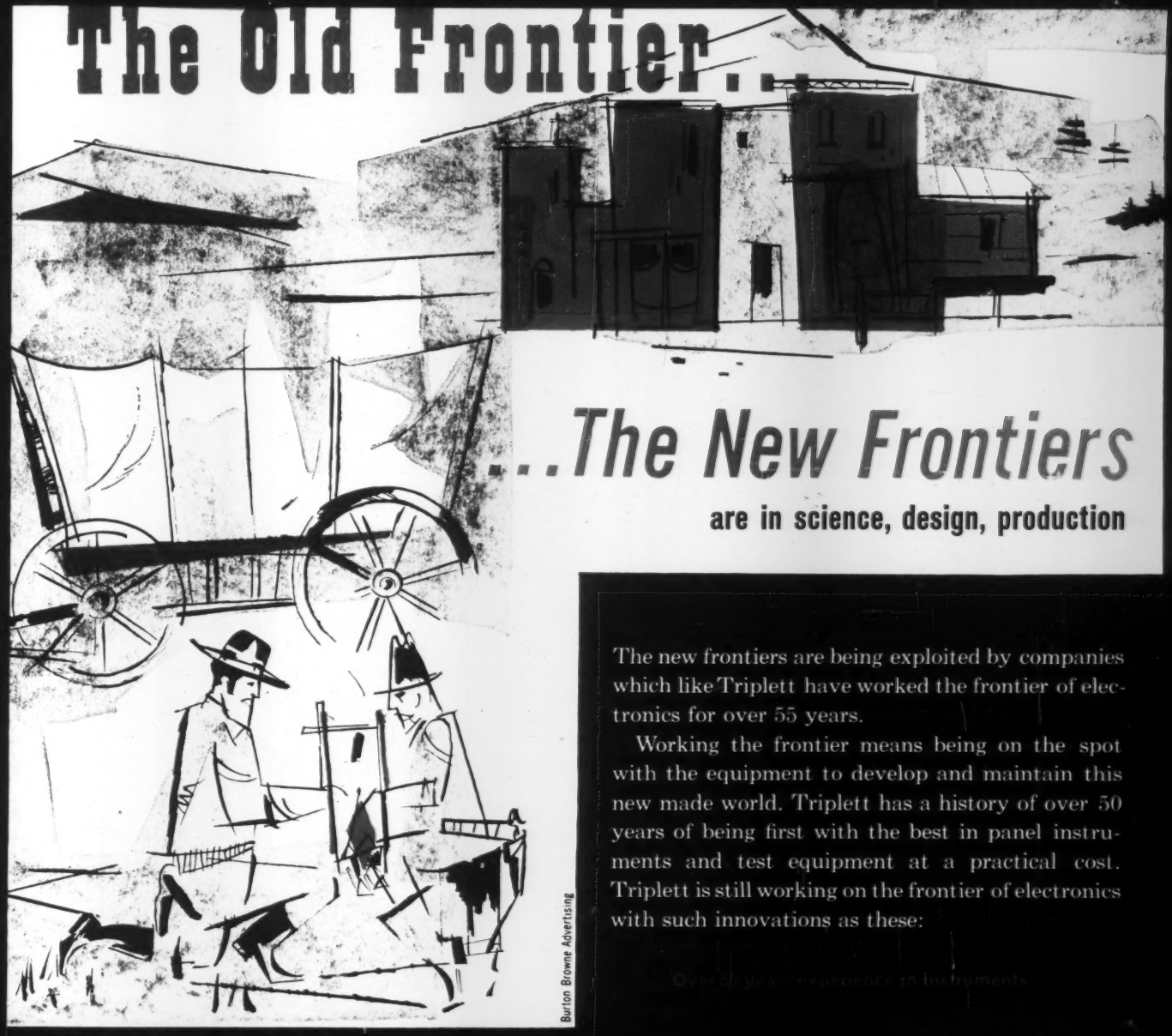
GUARANTEED UNINTERRUPTED REPAIR SERVICE

For more information circle **26** on inquiry card.

Circle **27** on inquiry card. ⟶

The Old Frontier...



...The New Frontiers

are in science, design, production

The new frontiers are being exploited by companies which like Triplett have worked the frontier of electronics for over 55 years.

Working the frontier means being on the spot with the equipment to develop and maintain this new made world. Triplett has a history of over 50 years of being first with the best in panel instruments and test equipment at a practical cost. Triplett is still working on the frontier of electronics with such innovations as these:

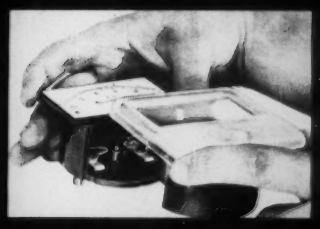
Over 50 years experience in instruments

Burton Browne Advertising

Model 310 a complete miniature V-O-M with single switch selection and the ranges and accuracy of units several times its size. Used with Model 10 clamp-on ammeter plugged in it becomes one of the world's most versatile pieces of test equipment—even measuring current flow without stripping wires.

Model 630-PL V-O-M with such advanced features as an unbreakable clear plastic front for wide range, shadowless, instant vision, polarity reversing switch, single king size knob for selecting both range and circuit, continuous resistance readings from 0.1 ohm to 100 megohms.

Model 690-A, a new Transistor Tester with more Triplett "plus" in accuracy and simplicity, for testing leakage and gain of all low and medium power PNP and NPN transistors. Small, rugged, battery-operated, it measures DC Beta from 5 to infinity. Affords exact tests for shorts, checks forward & reverse leakage of diodes. Features single switch selection of transistor types, positive "off" to prevent accidental battery drain, separate "calibrate" and "gain" buttons eliminate errors, transistor socket and external leads for any basing arrangement.

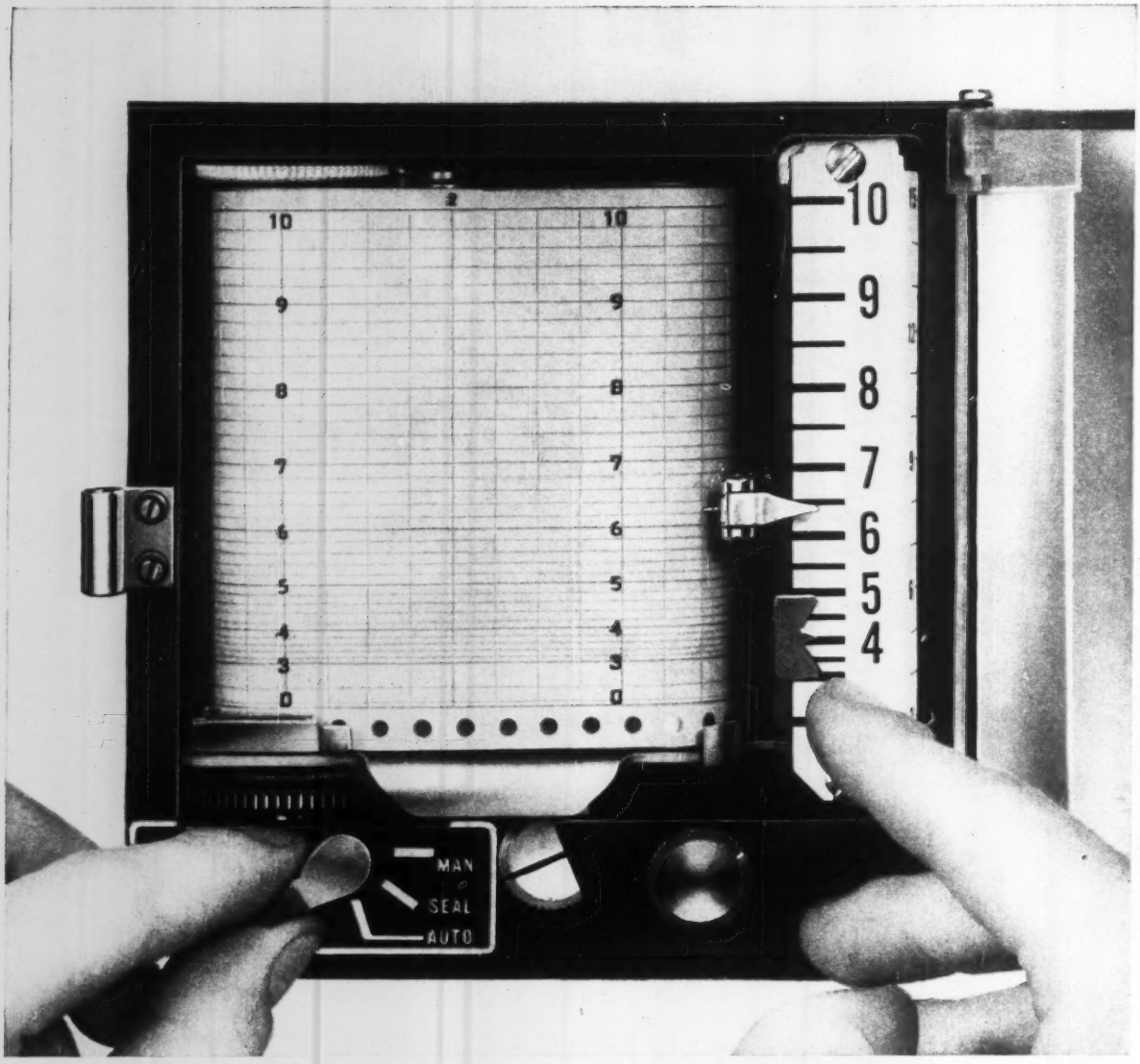


New Unimeters—a great step forward in increasing meter inventory flexibility while cutting inventory cost. These Select-Your-Range unimeters consist of only two basic meter movements, which can be combined with any one of a number of separate dial-component units for a wide variety of meter ranges. Movements quickly and simply slide onto dial-components and lock together—no soldering, no wiring. Exclusive Triplett Bar-Ring construction for self-shielding, greater accuracy and sensitivity.

TRIPLETT

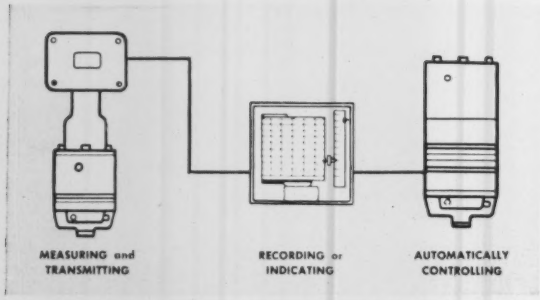
Triplett Electrical Instrument Company
Bluffton, Ohio

Throughout the world Triplett first . . . to last

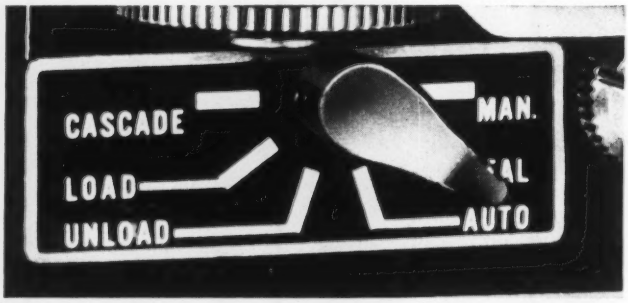


BRISTOL METAGRAPHIC RECEIVERS:

"Easiest 'bumpless



BRISTOL METAGRAPHIC INSTRUMENT SYSTEM



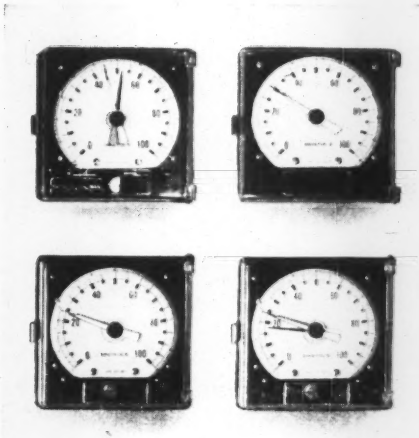
SIX-POSITION SINGLE-KNOB TRANSFER STATION (enlarged view) for cascade service. Three-position manual-automatic station is also available.

For more information circle **28** on inquiry card.

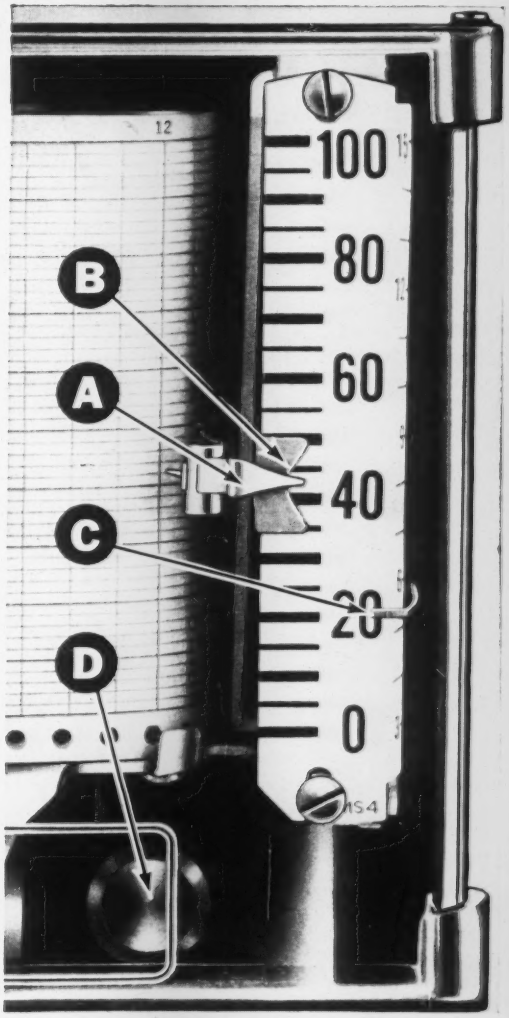
ONE OF 38 METAGRAPHIC RECEIVER MODELS you can choose from, all with 5" x 5¼" panel, all fitting into same 4 9/16" square panel cut-out. This Metagraphic Recording Receiver has single-knob six-position transfer station, gives easy start up and initial adjustment and completely "bumpless transfer" in complex cascaded control systems. Single-knob, six-position transfer station lets you select:

1. Completely automatic-cascade operation.
2. Automatic operation of slave loop alone.
3. Manual operation.

You get "bumpless transfer" both ways between all three conditions. This convenient switching greatly facilitates start-up of cascaded systems and initial adjustment of slave controller proportional, reset, and derivative actions.



METAGRAPHIC INDICATING RECEIVERS have full 9-inch scale for easy reading; feature: Complete 10-second interchangeability with recorders, show valve position as well as set point and controlled variable. Highly visible fluorescent paint on pointers makes deviation of set point and variable instantly apparent from as far as 20 feet away.



METAGRAPHIC RECEIVER shows measured variable (A), set point (B), and valve position (C), all on same scale. That's what makes manual-automatic transfer so easy, bumpless, and error-free with this instrument . . . just seal, match pointers with knob (D), transfer—that's all there is to it.

transfer' you ever saw"

That's what instrument men say after trying the Bristol Metagraphic Pneumatic Receiver—even in complex cascade control systems.

Just seal, match pointers, transfer. There's not a single value to read. It's that easy because the Metagraphic receiver gives you one-knob control plus continuous valve position indication on the same scale with set point and measured variable.

A genuine plug-in receiver. The Metagraphic is a *true* plug-in receiver—no finger-disconnects. *It plugs and unplugs in 5 seconds with no loss of automatic control. The case acts as a blind controller while the receiver is out.*

Don't pay for pre-installation errors. The Metagraphic's full plug-in versatility lets you switch from indicator to recorder in less than 10 seconds, interchange many receiver models, change recorder range simply by changing chart. Cuts down on costly reinstallations if process requirements are changed.

Write for the complete story on Bristol Metagraphic Receivers. Bristol gives you the widest selection of plug-in miniatures on the market—pneumatic, telemetering, electronic. (Full-sized instruments, too.) The Bristol Company, 113 Bristol Road, Waterbury 20, Conn. 7.33

BRISTOL *TRAIL-BLAZERS IN PROCESS INSTRUMENTATION*

AUTOMATIC CONTROLLING, RECORDING AND TELEMETERING INSTRUMENTS

For more information circle **28** on inquiry card.

briefs

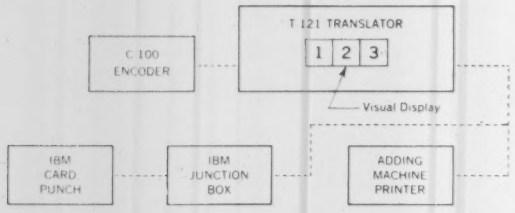
What is Draft?

Ask the average person what draft is and he'll say "It's the movement of air through a room," or "The flow of air through the furnace and up the chimney." But he is wrong because there is no movement to draft. It is what is called a "static" force. A force at rest but one that can produce energy if it is "turned loose" . . . Keep in mind that we human beings, our homes and our power plants are immersed in a gigantic "tank" of atmosphere more than fifty miles deep . . . When there is no fire in the furnace and dampers, doors, and chimney are left open, the pressure is the same inside and out and there is no draft. Now suppose we build a fire in the furnace then close the inlet dampers. What happens? The air in the chimney becomes heated, it expands and is now lighter than the air outside. This heated air has a tendency to rise, creating a partial vacuum in the combustion chamber. In other words the pressure in the combustion chamber is now less than the pressure of the outside air. This difference in pressure constitutes the draft . . . (*From new 20-page Bulletin 58-S201, in 4 parts, "How to Measure Draft," "Where to Measure Draft in a modern steam plant," "Where to connect draft gages," and "How to install draft gages," The Hays Corp., Michigan City, Ind.*)

For this literature circle **170** on inquiry card.

Digital Recording System

The K-120 System provides fully automatic or on demand digital recording on adding machine tape from many types of recorders made by L&N, Bristol, Honeywell —or from a shaft input . . . It incorporates a C-100A Series hollow shaft, shaft position-to-digital

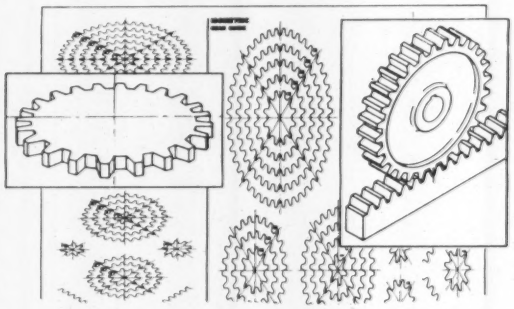


encoder, a Control Unit, and a Datex-Monroe Printer . . . The K-120 System provides for a readout of three decimal digits, such as 000 to 999 or 000 to 700, etc . . . The K-120 System can be used to obtain data while a shaft recorder is continuously following, or stopped. "On the fly" readout is obtained because the encoder position is stored in the Control Unit within 40 milliseconds of a readout actuation . . . (*From new 4-page Bulletin, Datex Corp., 1307 S. Myrtle Ave., Monrovia, Calif.*)

For this literature circle **171** on inquiry card.

Isometric Gear Guide

This guide is a fundamental underlay drawing aid providing a rack and twenty-one simplified spur gears having 6 to 48 teeth on the isometric plane. Diametral pitches of 8, 12, 16, and 24. The tooth form is based

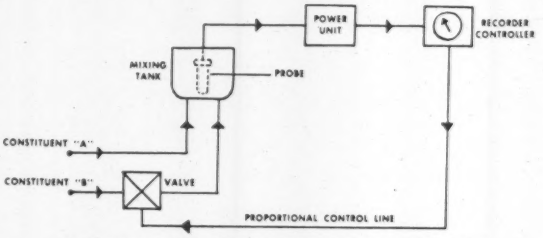


on the rack of the American Standard 20° involute system. Adaptable for all types of gears; also, splines, sprockets, cutters, rotors, tires, and many other circular forms having evenly spaced projections. May also be used for perspective . . . (*From new Bulletin and plastic 11″ x 14″ chart, Graphicraft, P. O. Box 509, Westport, Conn.*)

For this literature circle **172** on inquiry card.

Liquid Density Instrumentation

The PROBE is immersed directly in the liquid under observation; the top of the PROBE contains a spheroid plummet which is servo-suspended at an exact position under the pole of an electromagnet. The electrical energy required to suspend the plummet in the liquid varies with the density of the liquid. The electrical

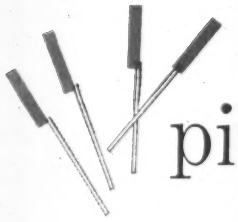


PROPORTIONING OF CONSTITUENTS IN FOOD PROCESSING

energy is converted in the POWER UNIT to a millivolt signal which, in turn, is fed to the INDICATOR or RECORDER together with appropriate zero-suppression voltage. The zero suppression is adjustable to the conditions involved and attenuation is provided in the signal itself to match the desired range and span of density to the sensitivity of the recorder. Since the plummet touches nothing but the liquid under test, friction and "spring characteristics" are eliminated. The design of a system will permit operation over an extremely wide range of static pressures and vacuums at any temperatures ordinarily encountered . . . (*From new 8-page Bulletin LDI-58, General Communication Co., 677 Beacon St., Boston 15, Mass.*)

For this literature circle **173** on inquiry card.

E101's are at work in aviation, petroleum, civil engineering, chemical, optical, pharmaceutical and other fields of science and industry. Engineers, statisticians, designers and researchers are saving costly time in handling their computational problems . . . from original design calculations, to the final test data reduction.



pinboard programming saves 95% of manual computation time!

Burroughs

electronic digital computer

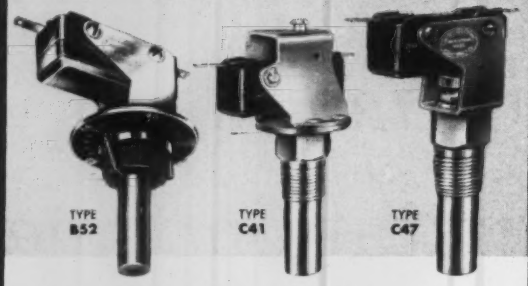
Users of Burroughs E101 low-cost digital computers report average time savings of 20 to 1 over desk calculators and other manual devices . . . plus superior accuracy. Savings in calculating time frees technical talent for more creative jobs . . . ensures better design . . . allows fuller employment of laboratory facilities . . . bigger work loads. Simplified pinboard programming can be mastered in a matter of hours. Problem solving capacity is further extended by optional PUNCHED PAPER TAPE INPUT/OUTPUT equipment and the NEW PUNCHED CARD INPUT unit, for direct computer processing of punched card files. For brochure, write ElectroData Division, Pasadena, California.

Burroughs Corporation

"NEW DIMENSIONS/in electronics and data processing systems"

For more information circle **29** on inquiry card.

SPACE OR WEIGHT LIMITATIONS? B52 | C41 | C47



Specify Local Mounted UE SKELETON TYPE TEMPERATURE CONTROLS

UNITED ELECTRIC temperature controls are precision-built, compact and economical. Type B-52 was designed especially for controlling air temperatures . . . Type C41 and C47 for liquid or hot plate temperatures . . . These controls are direct-immersion units designed for easy installation.

Temperature Ranges	Type C41 & C47 100° or 200° between 0° and 425° F limits. Type B52 calibrated 40° F spans between 30° and 120° F.
Thermal Assemblies	various immersion lengths . . . liquid-filled seamless brass bellows operate by hydraulic action
Switch Ratings	15 amps or 20 amps at 115 or 230 volts A.C.; also D.C. switches available upon specification
Switch Actions	N.O., N.C., or Double Throw, no neutral position
Electrical Connection	attached directly to screw or solder terminals on switch
Size & Weight	approx. weight . . . 4½ oz., approx. size . . . 3⅞" x 2" x 1¼"
Variations	design variations available upon specification

UNITED ELECTRIC *manufactures a complete line of temperature, pressure and vacuum controls. For applications requiring custom-built units or modified standard units, call upon a UE application engineer for recommendations. Write for complete specification and pricing data on the Type B52, Type C41 or Type C47 local mounted temperature control, and for information regarding other United Electric temperature controls.*

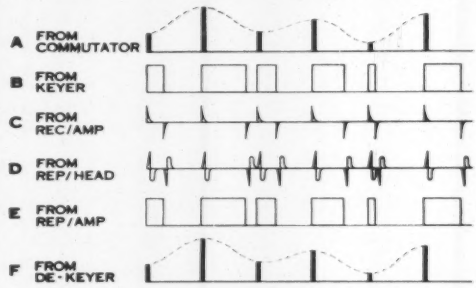
United Electric Controls COMPANY
85 SCHOOL STREET, WATERTOWN, MASS

For more information circle **30** on inquiry card.

Tape Recorder Techniques

The *Direct Recording Process* is the one having the widest frequency spectrum. Using practical tape speeds, signals can be recorded over a continuous range of frequencies from 50 cps to 100,000 cps. . .

The advantages of the *Frequency Modulation Recording Process* are: (1) its ability to record low



frequencies down to DC: (2) its freedom from the effects of tape drop-outs; and (3) its excellent phase-shift versus frequency characteristics with the attendant ability of accurately preserving the waveform of a recorded signal . . .

The chief advantage of the *Pulse-Duration Modulation Recording Process* is its ability to record a large number of simultaneous channels of information . . .

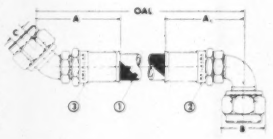
A fourth technique of recording is the *Digital Recording Process*, which has been growing rapidly in importance as a result of the wide-spread application of digital computers to electronic data processing systems. As in the PDM system, a sampling technique is used to measure a varying signal . . . (*From new 76-page Booklet "The Tape Recorder as an Instrumentation Device" by Paul J. Weber, Ampex Corp., 934 Charter St., Redwood City, Calif.*)

For this literature circle **174** on inquiry card.

Teflon Hose Assemblies

Extruded in tubing form, Teflon is an ideal flexible hose used to convey fluids, etc., or as a special purpose conduit. Typical hose assembly: core of Teflon; reinforcing wire braiding over core; and fittings

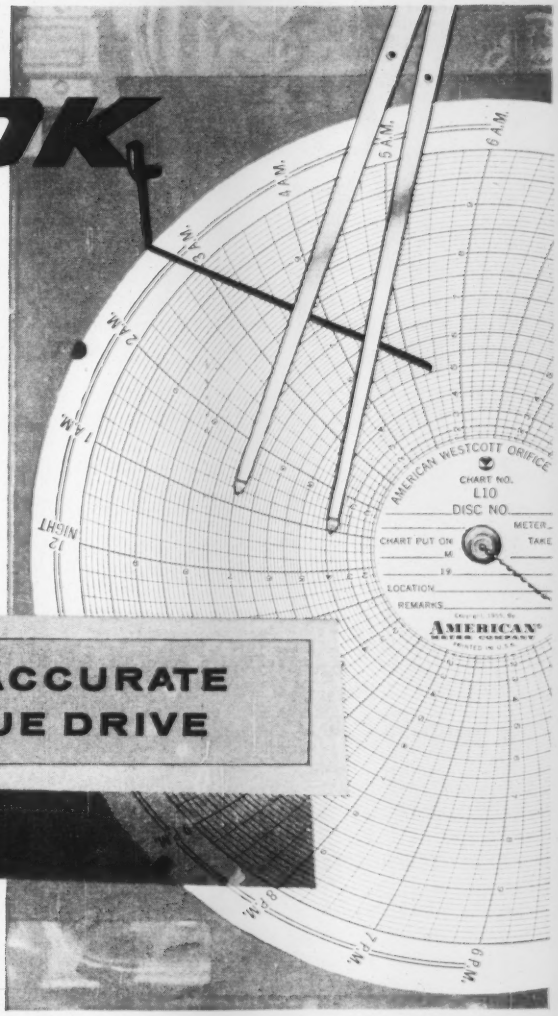
Size Dash No		–3	–4	–5	–6
Reference	1	T-1 3	T-1 4	T-1 5	T-1 6
	2	T-1200-3	T-1200-4	T-1200-5	T-1200-6
	3	T-1100-3	T-1100-4	T-1100-5	T-1100-6
	A	1.234	1.277	1.466	1.591
	A_1	1.104	1.166	1.348	1.481
	B	506	651	723	796
	C Min	080	332	781	256
	T	3/8-24 UNF 3B	7/16-20 UNF 3B	1/2-20 UNF 3B	9/16-18 UNF 3B



attached . . . T-104 Hose Assembly consists of Hose T-1 [inner core of Teflon, stainless steel wire braid (Type 304 alloy)]; Fittings T-1100 [stainless steel fittings for flexible hose of teflon (stainless steel, female, 37° swivel)]; T-1200 [stainless steel fittings for flexible hose of Teflon (female 37° swivel 90° elbow)] . . . (*From new 20-page Bulletin No. TC-101, The American Brass Co., American Metal Hose Div., 25 Broadway, New York 4, N. Y.*)

For this literature circle **175** on inquiry card.

AMERICAN® GASCLOK POWER DRIVE



VERSATILE • ACCURATE HIGH TORQUE DRIVE

Check these features--

- Completely self-contained gas or air-powered instrument driving and timing unit for long, trouble-free operation in remote locations.
- Constant high power...more than 20 times the torque delivered by conventional spring-wound mechanisms.
- Timing accuracy continuous...no heavy "mainspring" to weaken or run down...unaffected by a ± 20% variation in supply pressure.
- Self-starting...no winding or priming of power unit.

- Flexibility...ideal as original or replacement equipment for strip chart and conventional circular chart instruments.
- Built-in durability...timing mechanism internally sealed to prevent corrosion...large area internal ports prevent clogging.
- Rugged dependability...all power unit parts exposed to gas are aluminum or stainless steel...inherently explosion proof.
- Economical...normal air or gas consumption 5 cfh...operating pressure 5 psi...rotation 2 rpm.

Then ask your American representative how the versatile **GASCLOK** can provide new metering accuracies and economies for you.

AMERICAN® METER COMPANY

INCORPORATED (ESTABLISHED 1836)

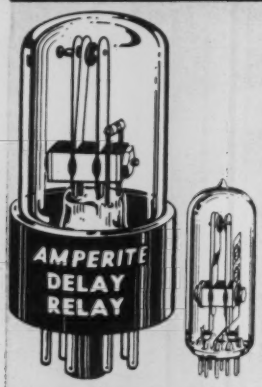
GENERAL SALES OFFICE: Philadelphia 16, Penna. • Albany • Alhambra • Atlanta Baltimore • Birmingham • Boston • Chicago • Dallas • Denver • Erie • Houston Kansas City • Los Angeles • Minneapolis • New York • Omaha • Pittsburgh • San Francisco • Seattle • Tulsa • Wynnewood • IN CANADA: Canadian Meter Company, Ltd., Milton, Ontario • Calgary • Edmonton • Regina

SUPPLIERS TO THE GAS INDUSTRY for Ironcase, Tinned Steelcase, Aluminumcase and Welded Steelcase Meters • American-Westcott Orifice Meters • Instruments • Reliance Regulators • Apparatus • Valves

For more information circle **31** on inquiry card.

AMPERITE

THERMOSTATIC
DELAY RELAYS



2 to 180 Seconds

Actuated by a heater, they operate on A.C., D.C., or Pulsating Current.

Hermetically sealed. Not affected by altitude, moisture, or climate changes.

SPST only—normally open or closed.

Compensated for ambient temperature changes from —55° to +70° C. Heaters consume approximately 2 W. and may be operated continuously. The units are **rugged, explosion-proof, long-lived, and—inexpensive!**

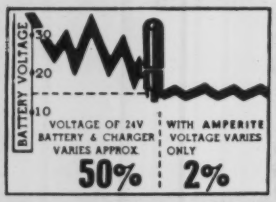
TYPES: Standard Radio Octal, and 9-Pin Miniature . . **List Price, $4.00.** Standard Delays

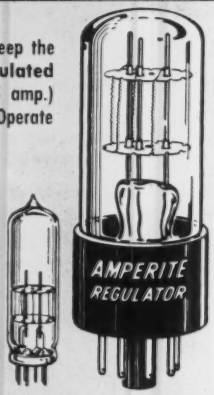
Also — **Amperite Differential Relays:** Used for automatic overload, under-voltage or under-current protection.

PROBLEM? Send for Bulletin No. TR-81

AMPERITE
BALLAST REGULATORS

Amperite Regulators are designed to keep the current in a circuit **automatically regulated** at a definite value (for example, 0.5 amp.) . . . For currents of 60 ma. to 5 amps. Operate on A.C., D.C., or Pulsating Current.





Hermetically sealed, they are not affected by changes in altitude, ambient temperature (—55° to +90° C.), or humidity . . . Rugged, light, compact, most inexpensive . . . . . **List Price, $3.00.**

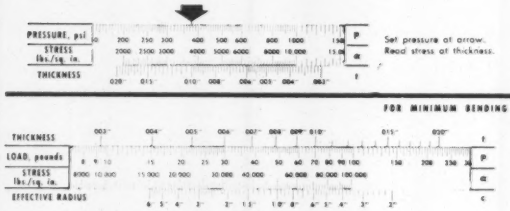
Write for 4-page Technical Bulletin No. AB-51

AMPERITE
561 Broadway, New York 12, N. Y. . . . CAnal 6-1446
In Canada: Atlas Radio Corp., Ltd., 50 Wingold Ave., Toronto 10

For more information on Delay Relays circle **32** on inquiry card.
For more information on Ballast Regulations circle **33** on inquiry card.

Bellows Design

The spring rate of welded metal bellows can be approximated by use of the Belfab slide calculator The calculator gives spring rate per convolution. Divide by the number of convolutions to determine spring rate of the whole bellows. In this connection, where the bellows is connected to end fittings by an O. D. weld, ½



convolution must be considered as "dead" for each such end connection . . . The slide calculator within a tolerance of 20%, gives the lowest possible spring rate per convolution for any selected combination of material thickness (t), Young's Modulus (E), and span (L) . . . *From new 20-page "Bellows Design Manual" (price $1.00), and slide-rule calculator, The Belfab Corp., Ramah Circle, Agawam, Mass.*

For this literature circle **176** on inquiry card.

Continued on page 41

MICRO-SMOOTH MINIATURE
SHAFTS, PIVOTS and TUBES
for INSTRUMENTS

Shafts and pivots are engineer designed and manufactured to a hardness in excess of 880 Vickers having a metallographic finish in diameter ranging from .013" to .160". Miniature tubes, cut and fabricated in a variety of materials, from the smallest to ⅜" diameter. Production quantity prices available.

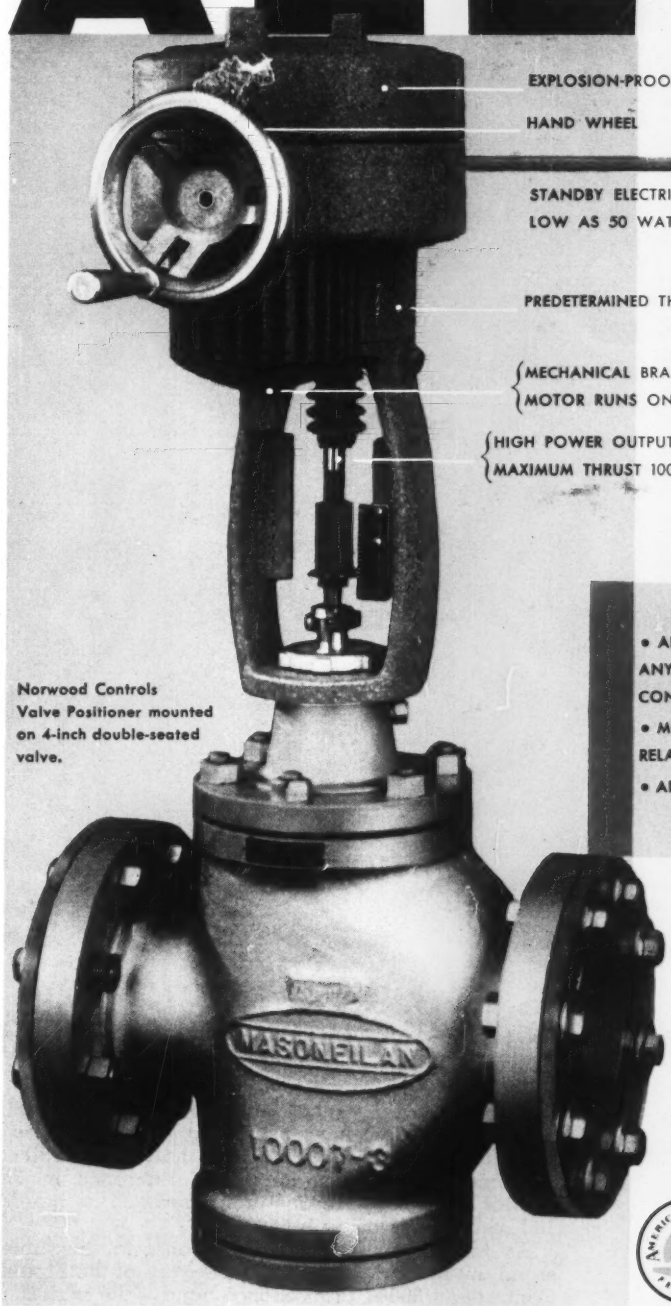
WE NOW HAVE NEW FACILITIES FOR MANUFACTURE OF SMALL SCREW MACHINE PARTS

Welton V. Johnson
ENGINEERING COMPANY
93 SUMMIT AVENUE • SUMMIT, N. J.

For more information circle **71** on inquiry card.

NO OIL – NO AIR . . . NORWOOD CONTROLS VALVE POSITIONER IS

ALL ELECTRIC



Norwood Controls Valve Positioner mounted on 4-inch double-seated valve.

EXPLOSION-PROOF

HAND WHEEL

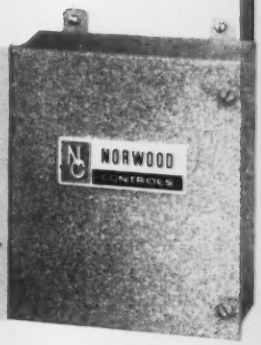
STANDBY ELECTRIC POWER LOW AS 50 WATTS

PREDETERMINED THRUST LIMIT

MECHANICAL BRAKE
MOTOR RUNS ONLY WHEN STEM MOVES

HIGH POWER OUTPUT
MAXIMUM THRUST 1000 LBS.

- ADAPTS TO SIGNAL FROM ANY AVAILABLE ELECTRIC CONTROLLER
- MERCURY WETTED POWER RELAYS—VIRTUALLY INFINITE LIFE
- ADJUSTABLE STROKES ½" TO 2"

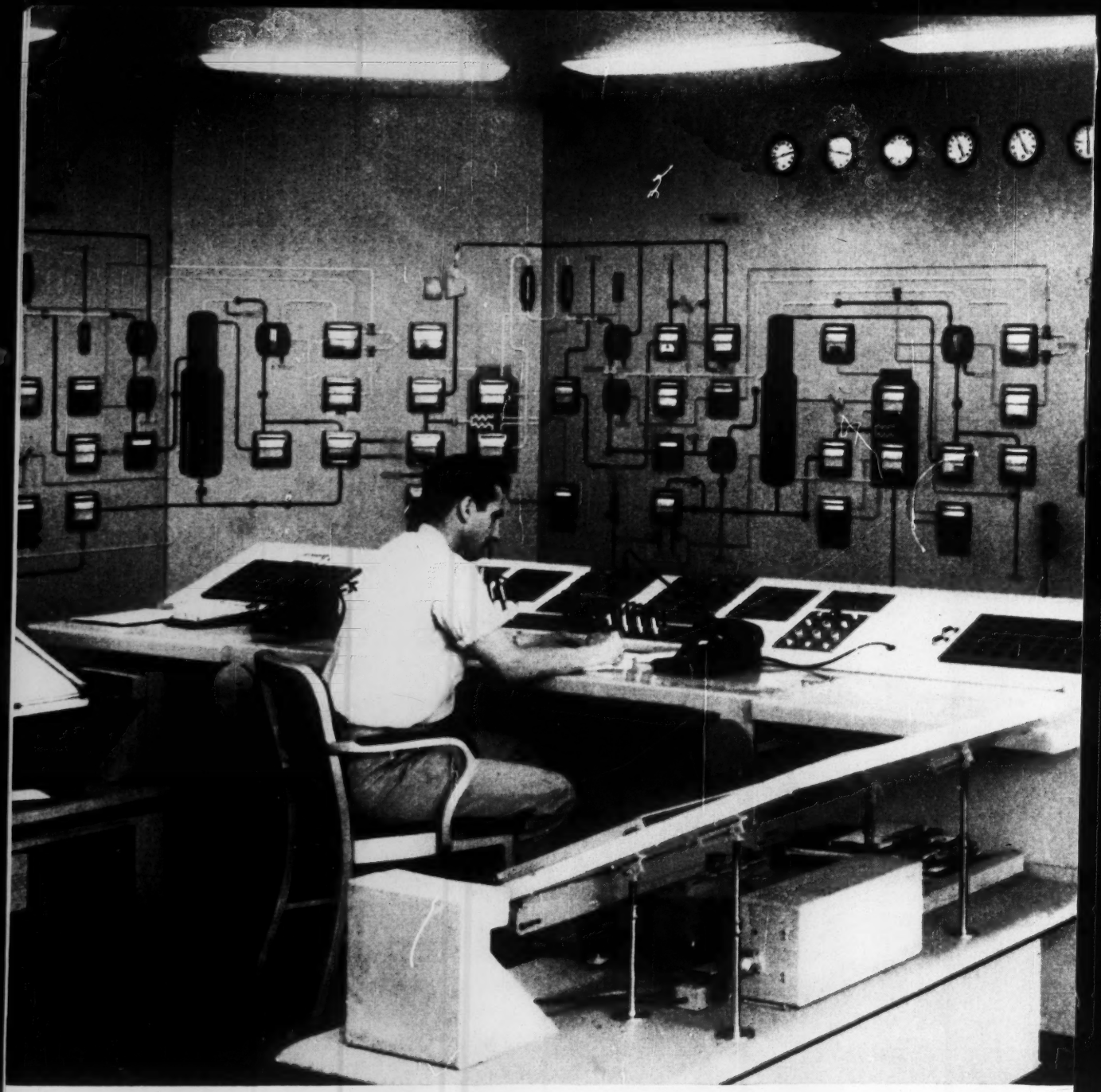


Maintenance problems drop almost to zero when you install Norwood Controls' new all-electric Valve Positioner. No air or hydraulic leaks, no cleaning, no expensive auxiliary equipment . . . just one, efficient, pre-lubricated, all-electric unit that operates from −40°F to 170°F.

For further information, write for data sheet B158-5. Norwood Controls Unit, Detroit Controls Division, 937 Washington Street, Norwood, Mass.

American-Standard
DETROIT CONTROLS DIVISION

For more information circle **34** on inquiry card.



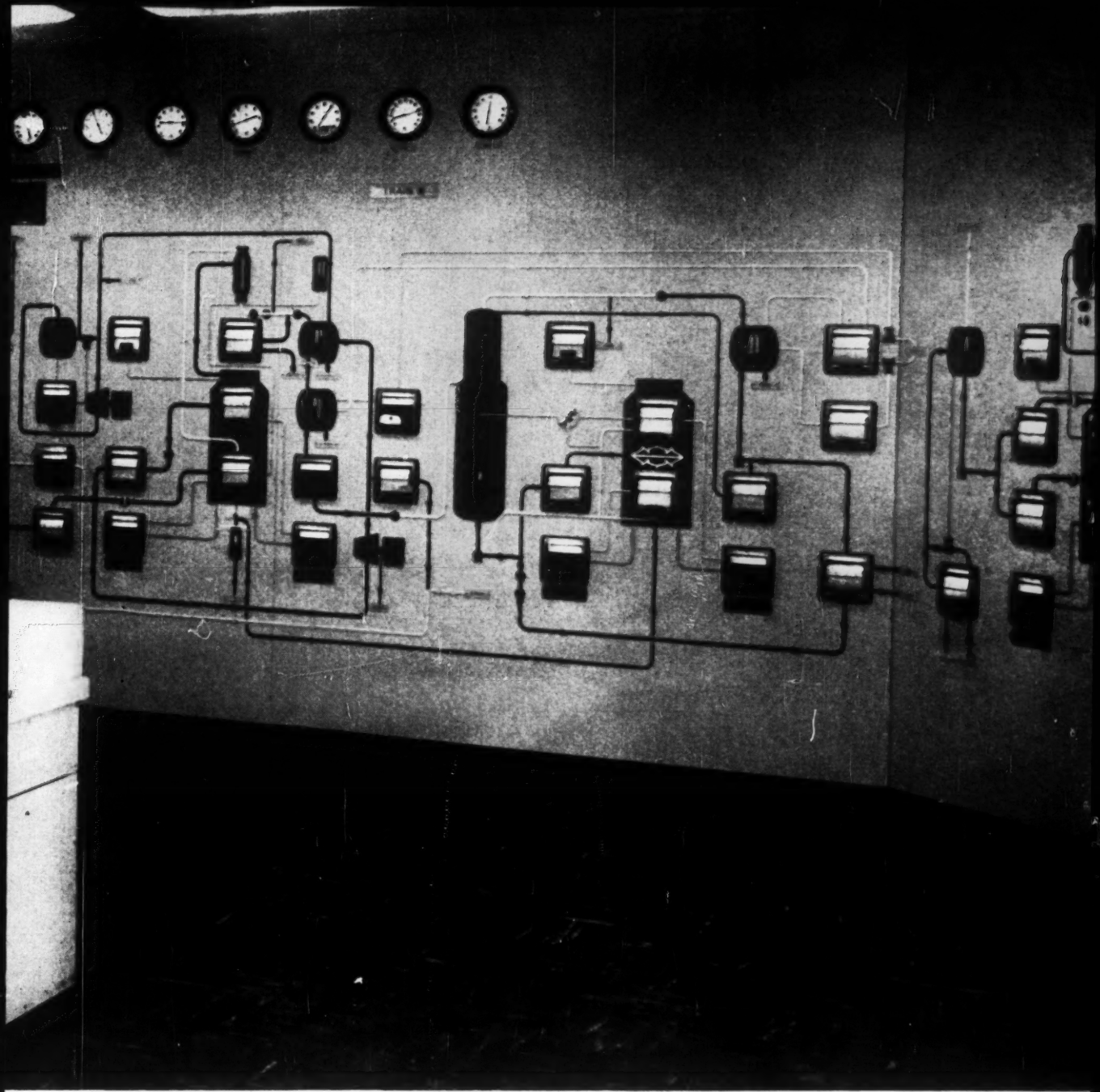
"readability and flexibility—that's why we specified

reports S. Edward Roth,
Chief Instrument Engineer,
Tidewater Oil Company
Delaware Refinery

It's the full-scale, vertical, 4-inch strip chart that makes a pneumatic Consotrol instrument so easy to read—even from a distance. 33% larger than most small-case instrument charts. An important difference in large control centers where operators "sweep" as many as 100 instruments at a time.

As for "flexibility", Foxboro Consotrol instruments stand out in two ways. One—because of the Model 58 Controller's 500% proportional band—the widest proportional band of any small case controller—and its reset and derivative units, which easily plug-in with *no* re-calibration necessary. Operators find these fea-

For more information circle **35** on inquiry card.



pneumatic Consotrols* for our new Tidewater Refinery"

tures especially helpful when "tuning" controllers to a new process.

And second—at the Tidewater Control Center shown here, there are 1, 2, and even 3-pen recorders; 1 and 2-pointer indicators; as well as recorders and indicators with integrally-mounted Model 58 Consotrol Controllers.

"Readability and flexibility"—plus day-in, day-out dependability of control. You get them all with Foxboro Consotrol instruments. Write for Bulletin 13-18—it has all the details. **The Foxboro Company, 461 Norfolk St., Foxboro, Massachusetts.**

*Reg. U. S. Pat. Off.

SHOWN ABOVE: Graphic control panel for catalytic desulfurizer unit. Tidewater Delaware Refinery. Over 400 Foxboro Consotrol Instruments are used in this ultramodern refinery.

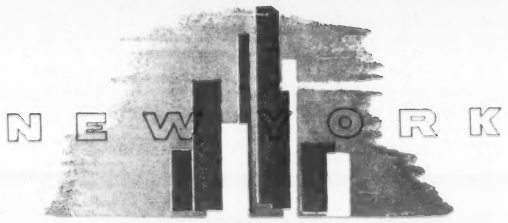
FOXBORO
REG. U.S. PAT. OFF.

CONSOTROL INSTRUMENTATION

For more information circle **35** on inquiry card.

"the show of the future"

FIFTH INTERNATIONAL automation EXPOSITION



NOVEMBER 16-20, 1959

Plan NOW to exhibit at the Fifth International Automation Exposition

As the nation's leading "automation" show, the Fifth International Automation Exposition is ideal for displaying equipment, components, and systems associated with industrial and scientific instrumentation, machine-tool control, computing, data and materials handling, and conveying.

Scheduled for November 16 to 20, 1959, at the New York Trade Show Building, the Exposition will again attract thousands of top executives and technical personnel from all industries.

Unique features of the New York Trade Show Building enable all exhibitors to schedule "clinics" for instructing selected audiences on the fine points of their equipment . . . in complete privacy . . . and featuring the equipment itself!

Make room now, in your promotion budget, for this most important show. Write for full details, and breakdown of attendance at previous International Automation Expositions.

Richard Rimbach Associates, Management

FIFTH INTERNATIONAL AUTOMATION EXPOSITION

845 Ridge Avenue, Pittsburgh 12, Penna. Phone FAirfax 1-9831 and 1-9832

You don't have to be over 21

to install and maintain

a Fenwal temperature indicating controller

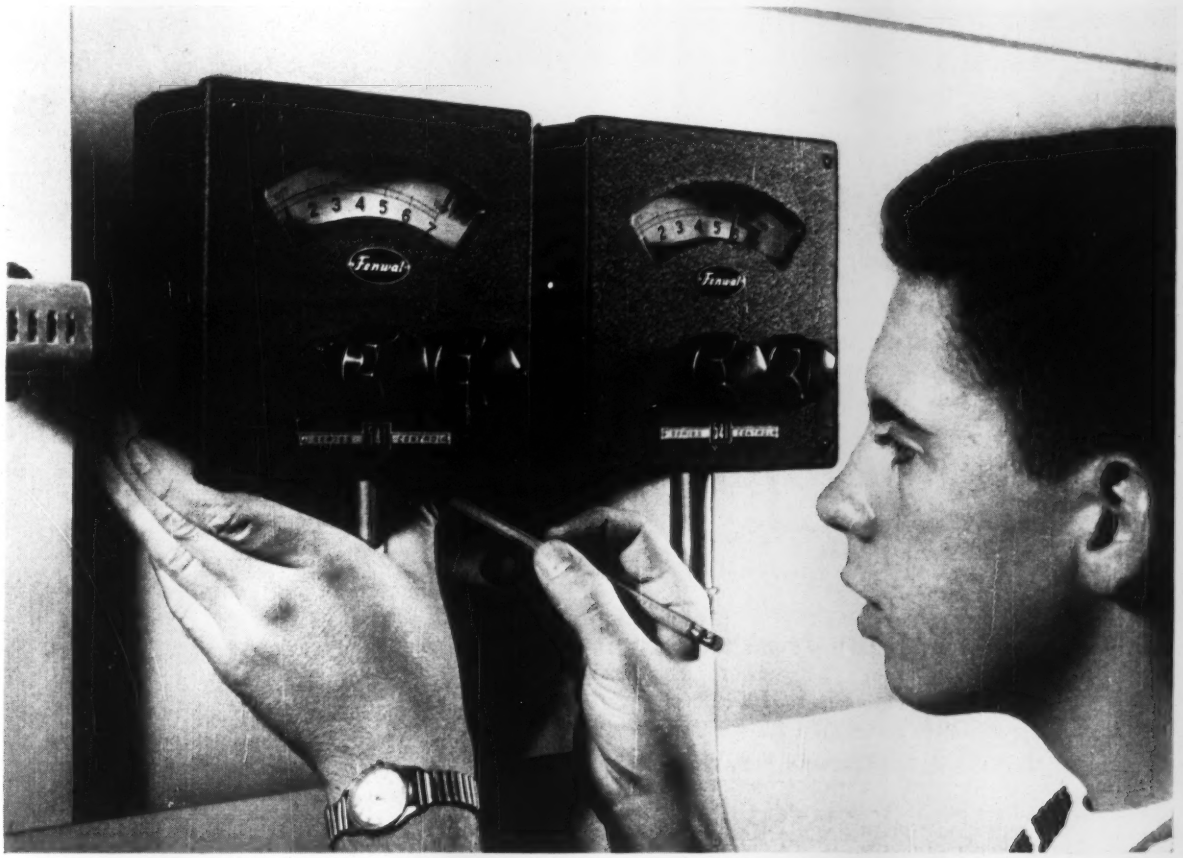
It really is a cinch for an untrained person to install and maintain Fenwal's 541 Temperature Indicator Controller. You don't even have to open the case to adjust it — even its snap switches can be easily replaced without disturbing the internal mechanism. *It's simple!*

In Fenwal's 541 all moving parts are in opposition — wear on one is automatically compensated for and the controller's high accuracy remains unchanged! *It's reliable!*

You can take your choice of temperature range, bulb styles, and one or two circuit controls, current ratings — even the color of the housing. There are literally hundreds of adaptations that can be made from stock! So you get a tailor-made, fit-to-order controller at a competitive price! *It's versatile!*

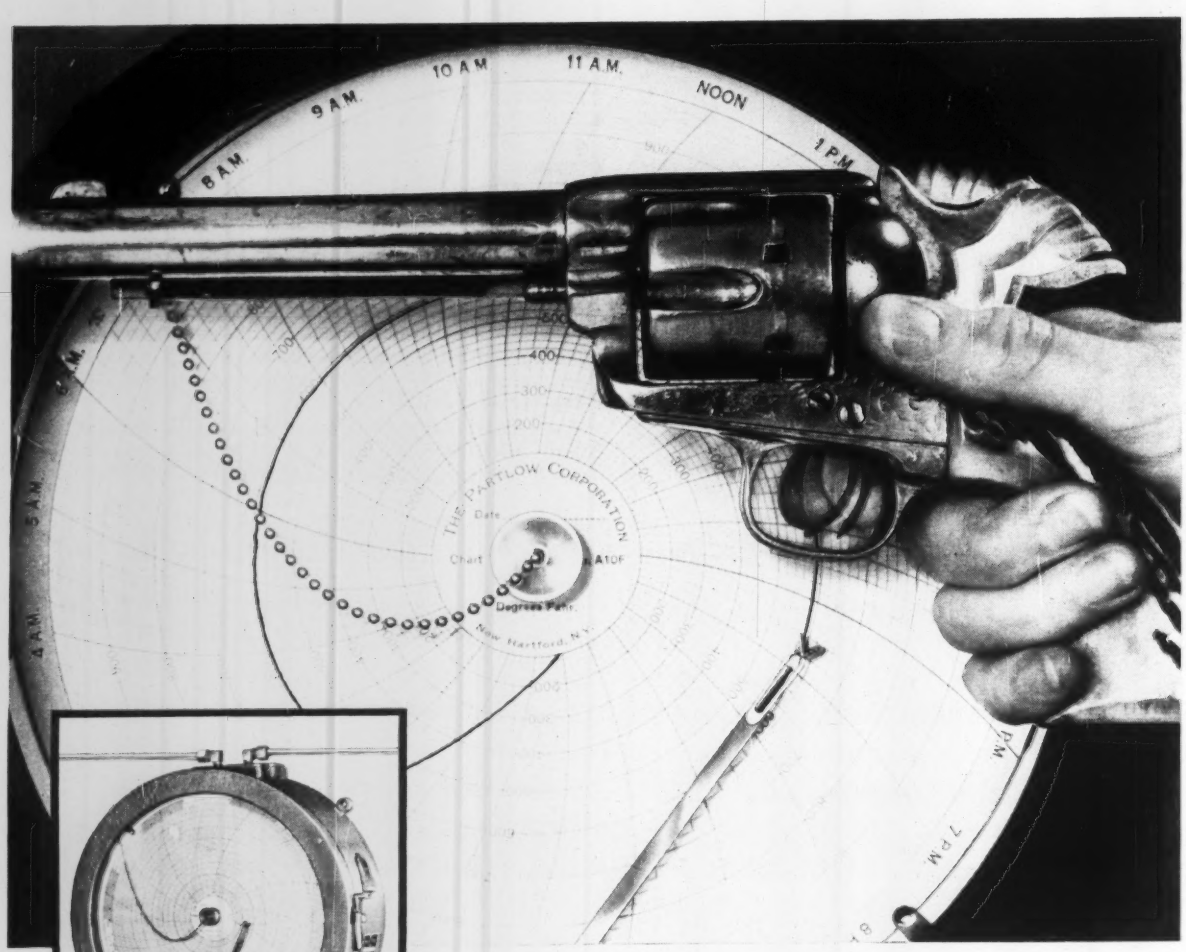
Drop us a line at Fenwal Incorporated, 361 Pleasant Street, Ashland, Mass. and we'll send you our catalog MC-139 or our sales engineer, whichever you want.

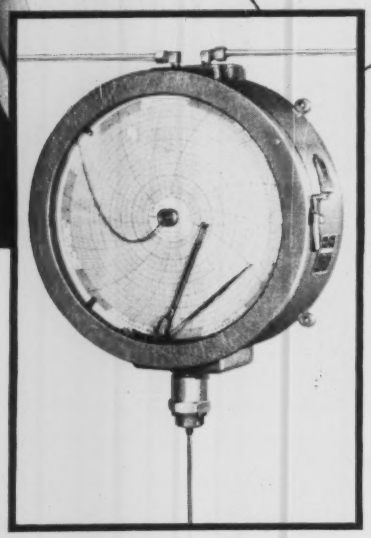
This is our dual circuit model (we've got hundreds of others) which has two snap switches, each with a set point indicator, that actuates two circuits at pre-set temperatures. Housing in all Fenwal 541's meet NEMA and JIC specifications.



Fenwal CONTROLS TEMPERATURE . . . PRECISELY

For more information circle **36** on inquiry card.





The Control Geared for

HAIR TRIGGER RESPONSE

even to Fractional Changes in Temperature!

NEW *Recording Pneumatic Temperature Control, Model RVA, available in any of 10 ranges from -30° to 1100° F.*

Extreme sensitivity—reflected in lightning-fast reaction to temperature changes—is a characteristic of *all* Partlow controls. Partlow Recording controls, however, *prove it in writing* . . . You can see for yourself how exceptional bulb sensitivity, teamed with advanced mechanical design, provide a minimum of "saw-toothing" on start-up, and maintain a rigid line of control when temperature reaches a predetermined set point.

Instant response, of course, is just one of Partlow's many built-in advantages. Another is rugged *design simplicity* that does away with hair springs and delicate electronic gadgets . . . that requires no electronic amplification . . . that permits fast, "screwdriver" replacement of the thermal element *right out in the field.*

If you use or manufacture process equipment within the -30° to 1100° F. range, there's a Partlow Pneumatic, electric or self contained gas control to fit your application *precisely*. Recording, indicating and non-indicating models available. For full details write The Partlow Corp., New Hartford, New York, Dept. IA-159.

You can pay more but you can't buy better than

PARTLOW

TEMPERATURE CONTROLS

For more information circle **37** on inquiry card.

BRIEFS—CONTINUED

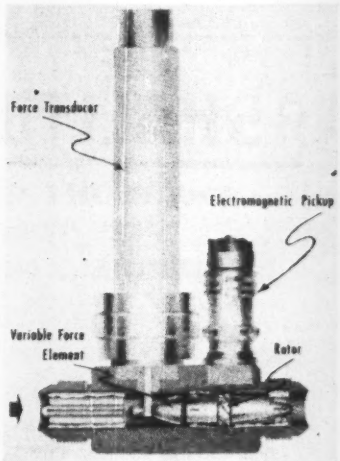
Programmed Pulses

Model 1020 Programmed Current Pulse Generator is a "packaged" instrument, designed to provide precisely controlled, fully programmed current pulses for research and development of digital systems and components . . . consists of four major circuit groups: Clock Timing and Pulse Generation, Program Generator, Program Delay, and Current Drivers. The Clock Pulse Generator provides basic internal timing for the system . . . the crystal diode Decoder selects one of its eight output lines . . . The Program Delay circuits operate to automatically inhibit flow of clock pulses to the binary counter at predetermined program steps, and for preset intervals of time . . . (*From new 4-page Bulletin 57-B, Rese Engineering, Inc., 731 Arch St., Phila. 6, Pa.*)

For this literature circle **177** on inquiry card.

Mass Flowmeter

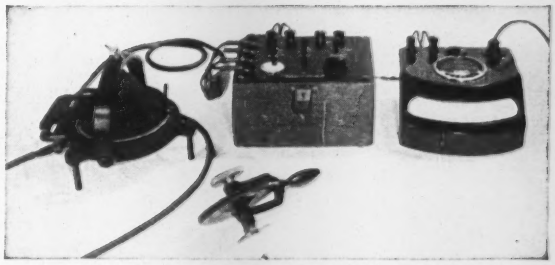
The F & P Mass Flowmeter consists of two hydraulically matched metering components, a variable force element which produces an output proportional to the volume rate of flow squared times the fluid density, and a volumetric transducer whose output is proportional to volume rate of flow. These two outputs are compared electronically to produce a signal which is directly proportional to the mass rate of flow.



Flow enters the upstream connection of the flowmeter body and . . . impinges upon the metering disc portion of the variable force element. The shape of this disc has been engineered such that its flow coefficient is identical to that of the volumetric transducer. The metering disc is integrally linked to a force transducer mounted on the meter body. Fluid force against this disc is thus converted to a proportional d-c signal . . . Flow past the rotor, which is fabricated of a magnetic stainless steel, causes it to turn, cutting through a magnetic field generated by a permanent magnet mounted in the pickup coil above it . . . (*From new Catalog Sheet 10G-1515, Fischer & Porter Co., 931 Jacksonville Rd., Hatboro, Penna.*)

For this literature circle **178** on inquiry card.

FOR TESTING FABRICS THAT MUST HOLD GAS



The Cambridge Fabric Permeameter is an accurate, rugged and convenient instrument for production testing of the permeability of fabrics which are to be inflated with Hydrogen, Helium, Carbon Dioxide, etc.

The rate of permeation through the fabric is quickly determined by equipment utilizing the thermal conductivity method and is indicated in terms of liters per square meter per 24 hours of the retained gas.

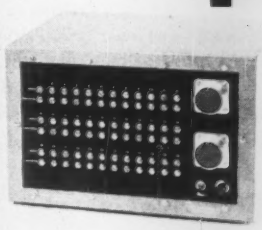
Manufacturers of fabrics for lighter-than-air Craft, Life Rafts, Life Jackets, Gas Masks, etc., will find this an indispensable instrument. Send for particulars.

CAMBRIDGE INSTRUMENT CO., INC.
3554 Grand Terminal, New York, N. Y.

CAMBRIDGE FABRIC PERMEAMETER

For more information circle **38** on inquiry card.

PACE



THERMOCOUPLE REFERENCE JUNCTION

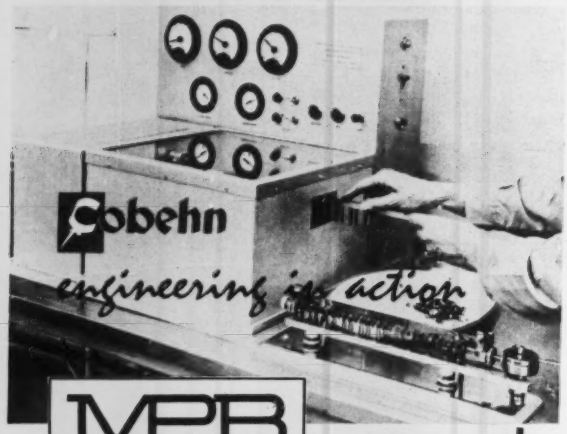
NEW BRJ SERIES UTILIZES MAGNETIC AMPLIFIER CONTROL FOR EXTREME PRECISION — 1/5°F STABILITY

- REFERENCE TEMPERATURES from 25° F above ambient to 250° F — *Special models for reference temperatures below ambient.*
- CHANNEL CAPACITY up to 48 channels in standard 110 volt rack or cabinet models.
- MULTI-WIRE junctions for thermocouple choice in each channel.
- THERMOCOUPLE TABLES for 150° F reference available. Write for your copy.

PACE *engineering company*
6914 Beck Avenue, North Hollywood, California • Phone POplar 5-0453

For more information circle **39** on inquiry card.

TO UPGRADE PRODUCTION . . .



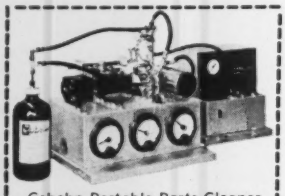
MPB automated bearing cleaning

One-at-a-time final cleaning of instrument bearings to rigid quality-control specifications slowed production at Miniature Precision Bearings, Inc., Keene, N.H. Bearing contaminants were removed with manually-operated spray equipment. To upgrade production, MPB, Inc., specified the Cobehn automatic parts cleaner. The model installed (illustrated above) thoroughly cleans 2400 precision instrument bearings an hour at an approximate cost of three mils per bearing.

Cobehn precision parts cleaners are engineered for use on assembly lines where large numbers of semi-conductors, gear-clusters, bearings and other small electronic and electro-mechanical components are cleaned on a continuous production schedule. Oil, grease, silicone lubricants, rosin flux and other foreign matter are safely and economically removed in seconds.

The Cobehn cleaning method provides:

- **a) Uniformity in cleaning technique;**
- **b) Close control over solvent costs;**
- **c) Controlled rotation of parts during cleaning;**
- **d) Elimination of chilling and condensation;**
- **e) Chemically cleaned parts without film, residue or corrosive effect. (Fractionally distilled Cobehn solvent far exceeds Fed. Specification P-S-661 b);**
- **f) Integral ventilation system.**



Cobehn Portable Parts Cleaner
Model No. 1-2BC-2S-2

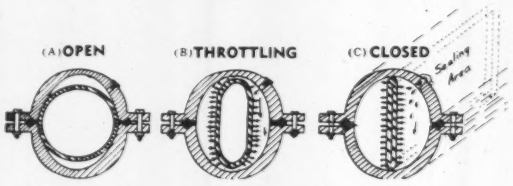
For specific information about your critical cleaning problems, send product information and production requirements. Our engineering report will be forwarded without delay.

Cobehn Inc.
Passaic Avenue
Caldwell, New Jersey

For more information circle **40** on inquiry card.

Sleeve Control Valve

The Red Jacket Valve operates by air or hydraulic pressure compressing the rubber sleeve. Pressure in the annular space between the valve body and sleeve does the work; as this pressure varies, the opening of the valve varies . . . The illustrations indicate the shape of the flexible sleeve from full open to full closed



position and demonstrate that the flow of material through the valve remains essentially unobstructed. (A) shows the full open position with straight through flow, full line size; (B) shows a throttling position with straight through, streamline flow; (C) shows the full closed position with large sealing area, which is 50% of the length of the sleeve . . . (*From new 16-page catalog binder, Red Jacket Co. Inc., 500 Bell Ave., Carnegie, Penna.*)

For this literature circle **179** on inquiry card.

MARSHALLTOWN

THE RIGHT GAUGE FOR YOUR SPECIFIC NEEDS

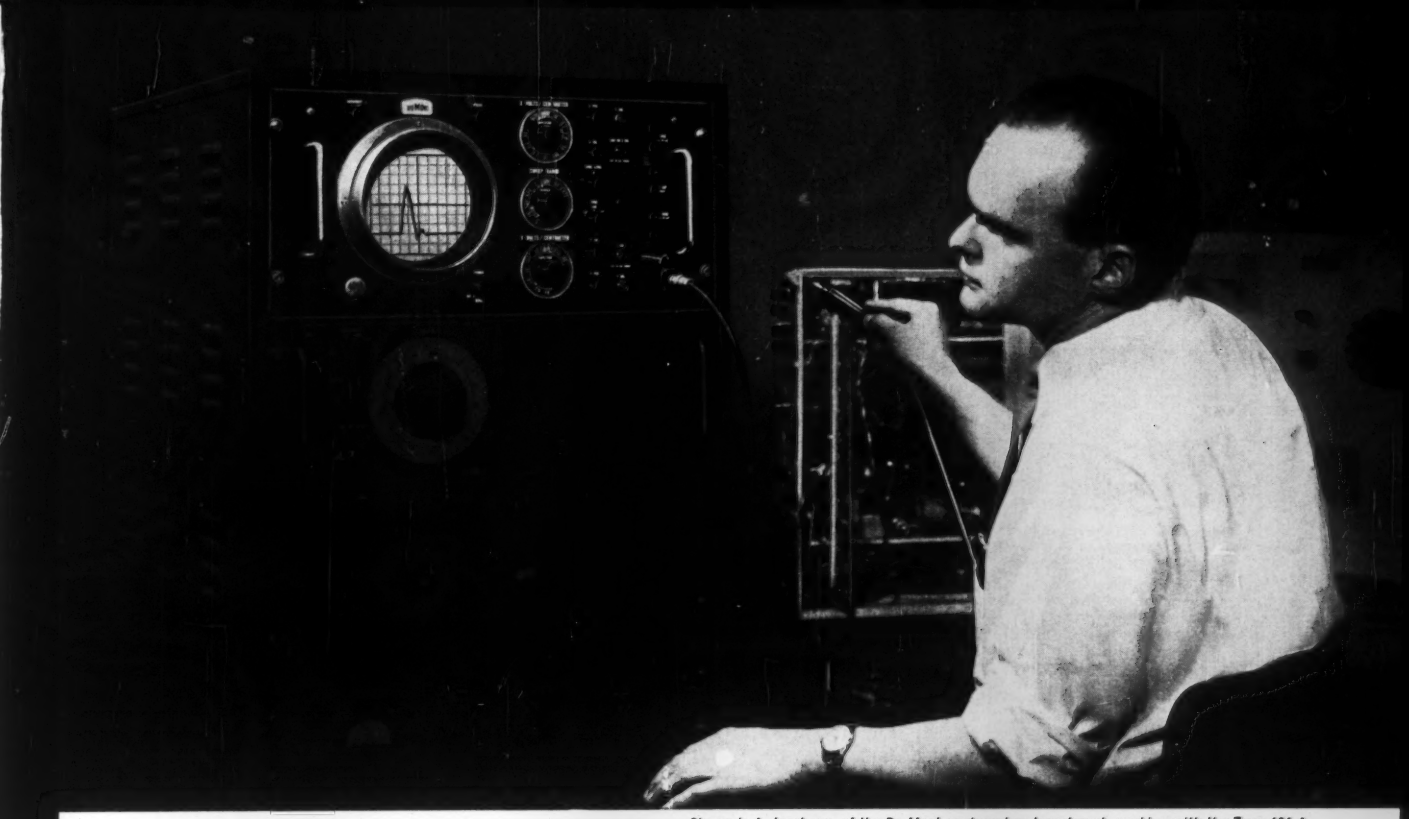
Available in a wide variety of general purpose and special purpose gauges in pressure ranges to meet your specifications in every particular.

- **PRESSURE**
- **VACUUM**
- **COMPOUND**
- **ALTITUDE**
- **COMBINATION**
- **DIAPHRAGM**
- **HYDRAULIC**
- **AND SPECIAL PURPOSE GAUGES**
- **DIAL THERMOMETERS (Vapor Tension or Bi-Metal)**

WRITE TODAY FOR COMPLETE INFORMATION

MARSHALLTOWN MFG. COMPANY
MARSHALLTOWN 3, IOWA

For more information circle **41** on inquiry card.



Shown is A. Jacobsen, of the Du Mont engineering department, working with the Type 401-A

THE SUPERLATIVE PERFORMANCE OF THE 401-A SCOPE IS AVAILABLE IN RACKMOUNTED VERSION

We have made considerable comment recently concerning the gratifying success of our 401-A scope, which has become—in its relatively brief history—the most popular instrument in the low-frequency range. However, we have been needlessly silent regarding this noble scope's brother instrument, the 401-AR, which also has been making a most enviable record for itself.

The 401-AR is electrically identical to the bench-type 401-A, and provides exactly the same high level of performance and dependability—the same high criteria of stability and accuracy—that characterize its much discussed counterpart. The only differences between the two units lie in the physical alterations required to adapt the scope for mounting in a standard 19-inch relay rack.

We would like to emphasize at this point that there is no difference in price between the rack-mounted and bench-type models. Both sell for $450.00 (FOB Clifton, New Jersey, U.S.A.)

For full information, call our representative in your area, or drop a line to us at the address below.

401-AR

RESUME OF PERFORMANCE SPECIFICATIONS

IDENTICAL X- AND Y- AMPLIFIERS
Sensitivity: 10 mv/cm (100 mv full scale).
Frequency Range: DC to 100 kc; down less than 3 db at 100 kc.
Calibration: Internal amplitude calibrator (both axes) with pre-set calibrated vernier detent points to eliminate need for recalibration after changing vernier gain control setting. Calibration accuracy, overall 5%.

SWEEPS
Range: Continuously variable from 250 msec/cm to 5 usec/cm.
Modes: Front panel selection of driven or automatic sweep.
Synchronization: Front panel selection of internal, external, or line on signals of either polarity.
Calibration: Direct-reading sweep calibration accurate to 5% overall.

CATHODE-RAY TUBES
Tight tolerance Du Mont Type 5ADP, operated at acceleration of 3000 v.

POWER SUPPLY
All operating potentials regulated. Choice of electronic regulation or self-regulating transformer. (No price differential)

DEPENDABILITY
Stability: Drift does not exceed 1 cm from center in 8-hour period, including 10% variations in line voltage.
Components: All components tested to exceed specifications. Hand-crafted wiring used throughout.

MECHANICAL
Dimensions: 8¾" high x 14⅝" wide (behind panel) x 18¾" deep behind panel, 20⅛" overall. Panel 19" wide.
Weight: Approximately 45 pounds.

DU MONT® INSTRUMENT DIVISION, ALLEN B. DU MONT LABORATORIES, INC., CLIFTON, NEW JERSEY, U.S.A.

For more information circle **42** on inquiry card.

Ammeters • Microammeters
Milliammeters • Voltmeters • Millivoltmeters
Megohmmeters • Multimeters

Combining the revolutionary BIFILAR frictionless movement with a weightless LIGHT-BEAM pointer, Greibach Precision Meters represent the most important advance in meter design in over 50 years. The patented Bifilar Movement replaces jewels, pivots and hair springs to provide virtually indestructible accuracy and sensitivity.

ONLY GREIBACH PRECISION METERS

offer these NEW STANDARDS of performance:

- ACCURACY to 0.25%, indefinitely
- SENSITIVITY to ¼ microampere, full scale (25 x 10^{-6} amps.)
- OVERLOAD up to 100,000 %
- SHOCK up to 500 g's on meter movement
- VOLTMETERS up to 5,000,000 ohms/volt
- ENERGY DISSIPATION as low as 1.2 x 10^{-7} watts
- REPEATABILITY of 0.1% or better without tapping

TRUE direct measurement for even the most hypercritical uses and conditions. Exclusive features now make GREIBACH Meters *THE* most reliable way to:

- check transistors, diodes, tubes, amplifiers
- test ionization and grid circuits
- meter extremely high voltages
- control by light-beam photocell operation

Greibach Precision Meters, for portable, bench or panel use, are available in 3 case models and with a wide selection of single and multiple ranges. Write for complete specification sheets.

GREIBACH INSTRUMENTS CORPORATION
315 NORTH AVE., NEW ROCHELLE, N.Y. • NE 3-7900

For more information circle **43** on inquiry card.

panhandle pete

WESCO! Expands After Market Research

Waldo Klapsaddle
Sales Manager, WESCO!

Dear Waldo:

We are looking for industrial growth companies that will diversify our operations. Many articles have appeared lately that point to instrument companies as promising in this respect. A small instrument company that makes servo-operated analog-to-digital converters has been brought to my attention. What is the market for such a device?

John Vandergelt
Chairman of the Board
WESCO!

* * *

David Land
Engineering Marketing Analyses, Inc.
New York, New York

Dear Mr. Land:

Do you have any information on the market for servo-operated analog-to-digital converters?

Waldo Klapsaddle
Sales Manager, WESCO!
Wheeling, W. Va.

Robert Q. Wilson
AAA Advertising Agency
Chicago, Ill.

Dear Mr. Wilson:

You handle the advertising for WESCO!, who have asked us about the market (size and potential) for servo-operated analog-to-digital converters. Do you have information on this? Will appreciate any data.

David Land
Engineering Market Analyses
New York, N. Y.

* * *

Horace Fortescue
Editor, *Modern Instruments*
New York, N. Y.

Dear Mr. Fortescue:

We are investigating the instrument market for a client who places much advertising. He is interested in the present and future market status of servo-operated, analog-to-digital converters. Do you have any information?

Robert Q. Wilson
AAA Advertising Agency
Chicago, Ill.

Henry Colegrove
Clipping File Clerk
Modern Instruments

Dear Hank:

A possible advertiser wants to know what the market is for servo-operated analog-to-digital converters. Any clips in your files?

Horace Fortescue, Editor
Modern Instruments

* * *

Dear Horace:

We have no clippings at all on servo-operated analog-to-digital converters. All I have is a clip that says that there are about 40 suppliers. Guess each one sells about a quarter million or so.

I get so many market inquiries I'm falling behind in my clipping filing.

Hank

* * * * *

Robert Wilson
AAA Advertising Agency
Chicago, Ill.

Dear Mr. Wilson:

After analysis of many sources, the Economics Bureau of MI Publications is pleased to supply you with the following statistics on the servo-operated analog-to-digital converter market:

No. of Suppliers: 40
Average volume: $260,000
Total Present volume: $10.4 million
Predicted 1960 volume: $20.80 million.

Horace Fortescue
Editor
Modern Instruments, an MI publication

* * * * *

Engineering Market Analyses
New York, N. Y.

Dear Mr. Land:

Our economic analysis of the market for servo-operated analog-to-digital converters is as follows:

1957: $10.4 to $12.2 million
1960: $20.8 to $24.4 million.

Owing to increased military expenditures, this is a promising item.

We welcome your inquiries and will serve your clients in all ways to find and explore new markets.

Robert Wilson
AAA Advertising Agency
Chicago, Ill.

Waldo Klapsaddle, Jr.
Sales Manager, WESCO!

Dear Mr. Klapsaddle:

After exhaustive analysis of the military and industrial markets, we find the servo-operated analog-to-digital converter market at $12.2 to $14 million for 1957. This should increase to between $24.4 to $28 million by 1960, owing to federal expenditures.

Bill for market analysis is enclosed.

David Land
Engineering Market Analyses
New York, N. Y.

* * * * *

John Vandergelt
Chairman of Board, WESCO!

Dear Mr. Vandergelt:

Our market analysis experts inform us that the market for servo-operated analog-to-digital converters is approximately $12 to $15 million in 1957. This is extrapolated on the basis of federal expenditures and industrial applications to reach $25 to $30 million by 1960.

Waldo Klapsaddle, Jr.
Sales Manager
WESCO!

NEWS ITEM TO ALL TRADE PUBLICATIONS

John Vandergelt, Chairman of the Board of WESCO! of Wheeling, W. Va., has announced purchase of X-Y-Z Electronics, which manufactures servo-operated analog-to-digital converters. Mr. Vandergelt announces that the market for such devices is now above $15 million and will increase to more than $30 million by 1960.

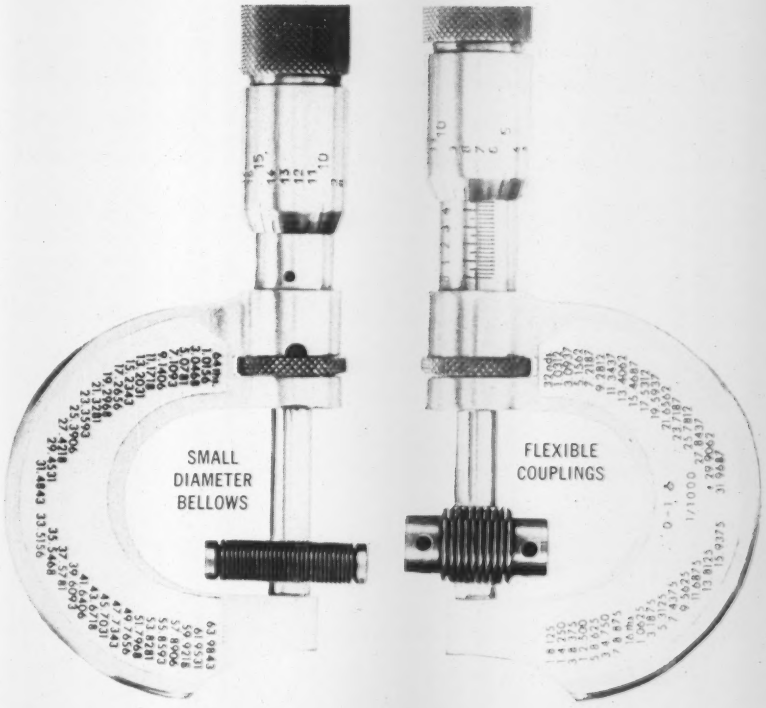
TREND ITEM IN MODERN ELECTRONICS MAGAZINE

Mr. Vandergelt, Chairman of the Board of WESCO!, reports the market for servo-operated analog-to-digital converters will soon be above $30 million, might reach $1 billion by 1970.

MEMO FROM HORACE FORTESCUE, EDITOR OF MODERN INSTRUMENTS TO HANK COLEGROVE, CLIPPINGS CLERK:

Dear Hank: Here is a clipping from *Modern Electronics* that shows that your estimate of the servo-operated analog-to-digital converter market was far too low. Keep this clipping for future inquiries on this market.

Panhandle Pete



MINIATURIZE WITH BRIDGEPORT

Looking for new ways to save space and weight in instruments, aircraft, missiles and other equipment? Investigate these two miniature products by Bridgeport:

Small Diameter Metallic Bellows, only ¼" and 5/16" O.D., provide exceptional strength, precision and sensitivity to temperature and pressure changes. Hydraulically formed without seams to your strictest specifications in a wide range of bellows metals, physical properties and performance characteristics. Available in unlimited quantities.

WRITE FOR BULLETIN F-101.

Small Diameter Flexible Couplings, available from stock, in several metals and sizes as small as 15/32" O.D. . . . smaller diameters custom-engineered on request. Eliminate back-lash, maintain uniform angular velocity, reduce bearing wear and friction in a variety of applications. Stock couplings accommodate shaft sizes ⅛" to ½" diameter.

WRITE FOR DATA SHEET F-801.

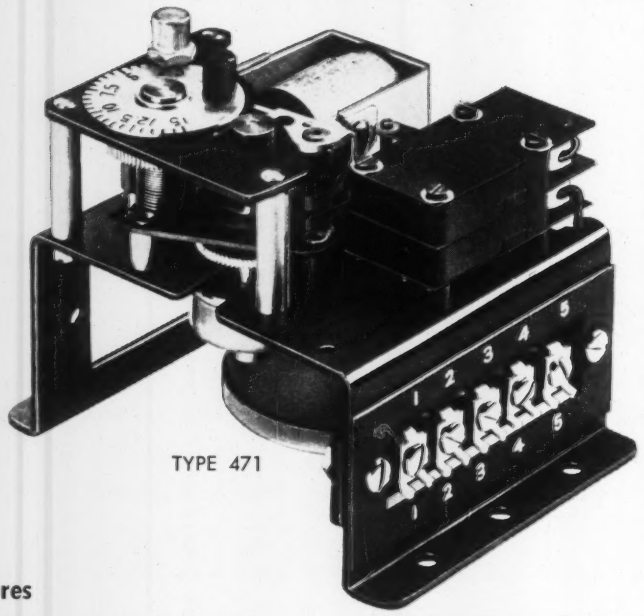
Mr. Controls
Robertshaw-Fulton
CONTROLS COMPANY

BRIDGEPORT THERMOSTAT DIVISION • Milford, Conn.

For more information circle **44** on inquiry card.

New adjustable time delay relay provides wide selection of time ranges

The new Cramer Type 471 Time Delay Relay provides an accurate, adjustable time delay between the operation of a control circuit and the subsequent closing or opening of one or two load circuits. Through selection of external wiring connections, the unit offers broad application flexibility and excellent accuracy at modest cost. Some typical uses include control of machine tools, batch processes, heat treating, automatic mixers, electronic devices, and signalling equipment of many kinds.



TYPE 471

Operation

Type 471 is powered by a Cramer synchronous motor which drives precision-cut timing cams through a clutch, from a starting point set by a dial knob. The cams rotate at constant speed to a zero point, where the load switch is transferred. An instant later, a second cam opens the motor circuit. The clutch stays engaged, and the unit does not reset until the operator either opens the clutch circuit for the direct-clutch model, or closes the clutch circuit for the reverse-clutch model.

The direct-clutch unit resets automatically on power interruption, and repeats its complete cycle when power is restored. The reverse-clutch unit simply suspends operation and, when power returns, proceeds to complete the same time interval. Resetting is accomplished by a coil spring which drives the cam carriage back to a movable stop which is positioned by the dial knob. The stop location determines how quickly the cams will reach the switch actuation points, and so determines the timed interval.

Features

TIME RANGES — 15 seconds to 24 hours.

ADJUSTMENT RANGE — 90% of full scale.

ACCURACY — within 2% of full scale.

RESET TIME — approx. ⅓ second or less.

LOAD SWITCHES — snap-acting SPDT, 10A 125V or 5A 250V AC, non-inductive.

MOTOR & CLUTCH — 115/220V, 25, 50 and 60 cycles. Reverse clutch optional.

GEARS — case-hardened steel, for life in excess of a million operations.

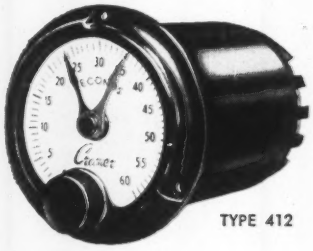
For details, write for your free copy of Bulletin PB-471.

TIME RANGES AND MINIMUM SETTINGS

TIME RANGE	DIAL DIVISIONS	MINIMUM SETTING
15 sec.	½ sec.	1.5 sec.
30 sec.	1 sec.	3 sec.
60 sec.	2 sec.	6 sec.
5 min.	10 sec.	30 sec.
15 min.	30 sec.	1.5 min.
30 min.	1 min.	3 min.
60 min.	2 min.	6 min.
2 hrs.	5 min.	12 min.
5 hrs.	15 min.	36 min.
12 hrs.	30 min.	1¼ hrs.
24 hrs.	1 hr.	2½ hrs.

FOR EXTREME ACCURACY PLUS WIDE SELECTION OF RANGES

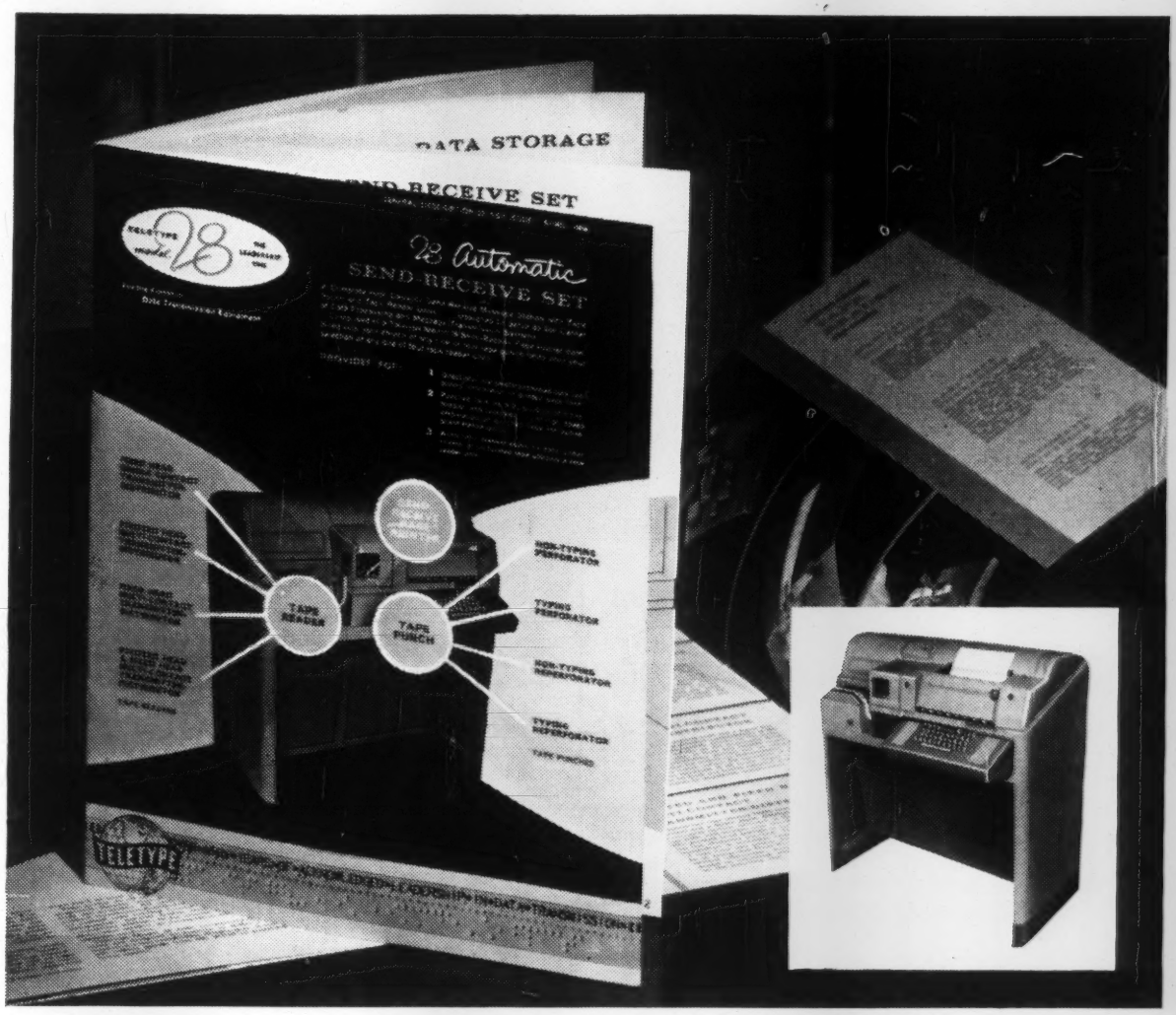
Type 412 performs essentially the same functions as Type 471, except that it is designed for panel mounting, extreme accuracy, heavier loads, and 100% adjustability over the entire time range of each unit. Eleven full-scale time ranges are available, from 6 seconds to 24 hours. Overall accuracy is within plus or minus ½ of 1% of full scale, exclusive of setting errors. Repeat accuracy is within plus or minus ¼ of 1% of full scale on 30 second and longer ranges, and ½ of 1% of full scale on faster timers. The fully enclosed dial carries a red pointer to indicate the setting, a black pointer to indicate timing progress. The open blade SPDT load switch is rated 15A 125V, 10A 250V AC, and can handle inrush currents up to 40 amperes. A second load, operating within 1% of full-scale time following the first load, can be controlled from the motor switch itself. Internal SPST seal-in contacts permit operation from a 1/10-sec. control pulse if desired. Direct or reverse clutch operation is as described for Type 471.



TYPE 412

CRAMER CONTROLS
CORPORATION
Box 5, Centerbrook, Connecticut

For more information circle **45** on inquiry card.



FREE– Teletype booklet ...details new 28 ASR

Contents—Includes information on:

- Automatic communications
- New transmission speed
- Tape punching
- Tape reading
- By-product tapes
- Printing on tape
- Printing on forms
- Data processing
- Data transmission
- Data storage
- Aids to IDP
- "Robot brain"
- Reducing "clerical lag"
- Etc.

This 16-page booklet describes the new Teletype Model 28 Automatic Send-Receive Set.

The Model 28 ASR is a "packaged" set—a single, compact console with a complete array of facilities—to serve as a center for your communication, data processing, paperwork simplification and automation systems. Operates at 100 WPM.

Please write for your free booklet on company letterhead.

Address: Teletype Corporation, Dept. 23 A, 4100 Fullerton Avenue, Chicago 39, Illinois.

TELETYPE®
CORPORATION
SUBSIDIARY OF *Western Electric Company* INC.

For more information circle **46** on inquiry card.

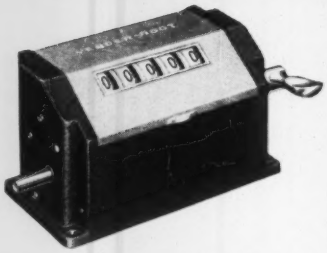
How can your customers Know ...unless your product can COUNT?

How can they know that they're getting out of your product all the performance you build into it — unless you *also* build into it a Veeder-Root Counter as a standard part? Then they have a running record of performance that shows them where they stand every minute of the working day . . . and a record that proves your product's guarantee. What's more, it gives you a new plus in selling.

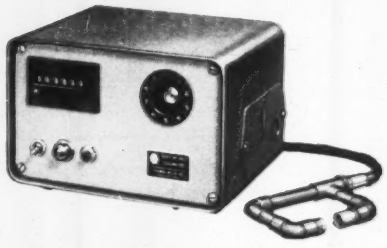
How to build it in? Count on us to show you. Write, or phone JAckson 7-7201.

You always "Know the score" when you count on Veeder-Root!

Vary-Tally Multiple Unit Hand-operated Counter. Easy keyboard action. All units on same row reset instantly to zero with one turn of knob. Supplied in practically any number of units, in any arrangement.



New High-Speed Predetermining Counter, Series 1522, features instant lever reset plus quick and easy setting of predetermined number. Speeds up to 6,000 rpm. Also supplied without predetermining feature.



New "Count-Pak", a complete electronic counting package for use where high speed, long life and instant reset are required. Rated at 20,000 counts per minute (with added decade speeds run up to 200,000 cpm). *Completely transistorized.* Photohead adaptable to any job. Several other "Count-Paks" available.

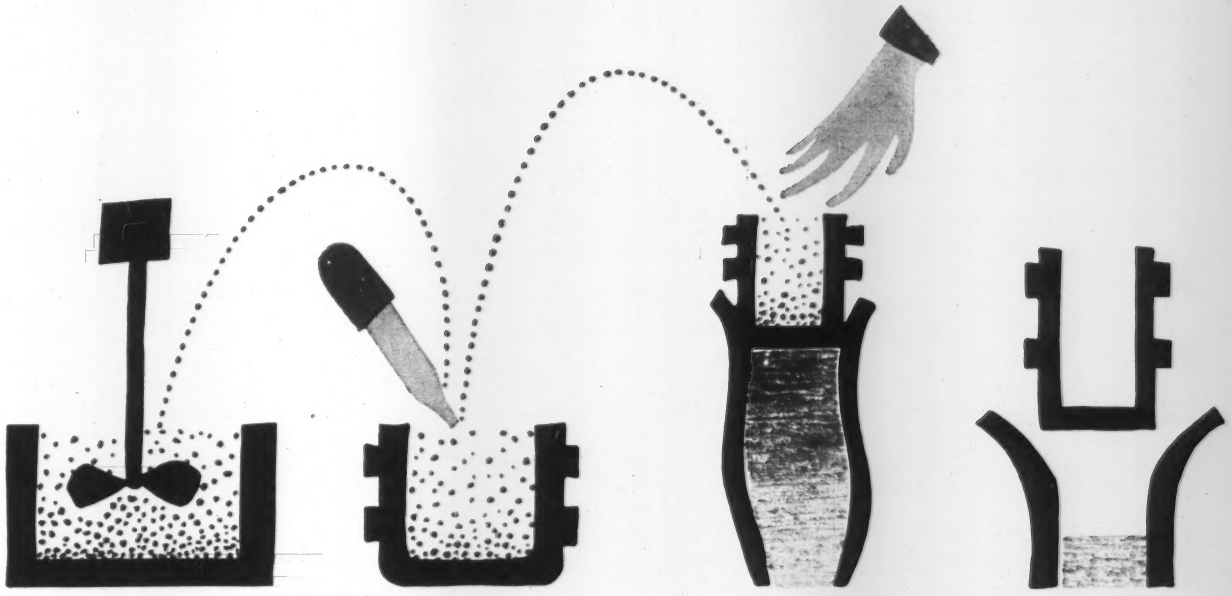
Everyone can Count on

Veeder-Root Inc.

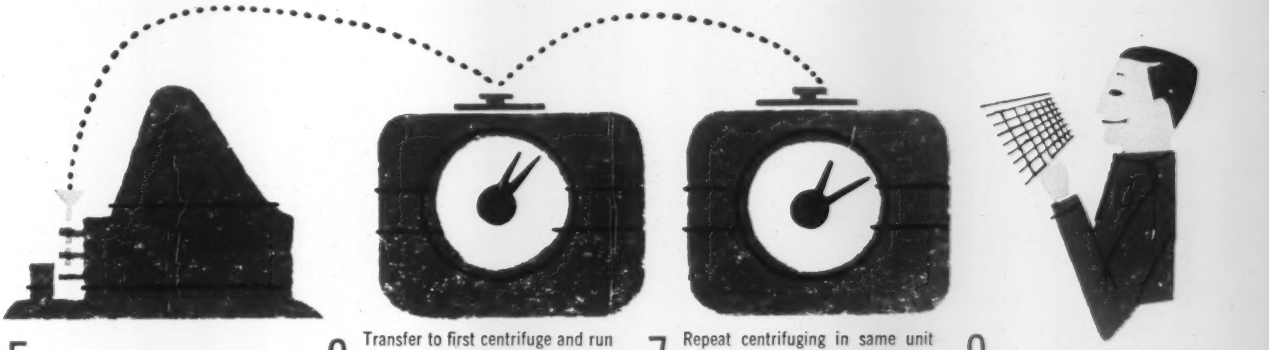
HARTFORD 2, CONNECTICUT

Hartford, Conn. • Greenville, S. C. • Altoona, Pa. • Chicago
New York • Los Angeles • San Francisco • Montreal
Offices and Agents in Principal Cities

For more information circle **47** on inquiry card.



1. Prepare suspension of particles.
2. Transfer suspension to feeding chamber.
3. Transfer feeding chamber to centrifuge tube.
4. Remove feeding chamber, leaving sharp layer of suspension on top of sedimentation liquid.



5. Read sediment height under gravity in projector at precalculated times.
6. Transfer to first centrifuge and run for precalculated time, then remove and read in projector.
7. Repeat centrifuging in same unit or in higher speed centrifuges until run is complete.
8. Size distribution is obtained from sediment height data.

New Low-Cost Way to Measure Size Distribution of Small Particles

With the new M-S-A® Particle Size Analyzer, you can start with a minimum investment for measuring particle distribution, and then expand it by the purchase of additional components.

This versatile analyzer is a general-purpose device for measuring size distribution of small particles. It is especially designed for measurement of subsieve particles between approximately 0.1 and 40 microns. Most airborne dusts, paint pigments, and many flours, chemicals, and pharmaceuticals lie within this range.

Complete analyzer system includes centrifuge tubes, feeding chamber, optical tube projector, one or more special centrifuges, and tube handling and cleaning accessories. Write for new bulletin for details.

Tube Projector

Centrifuges

MSA

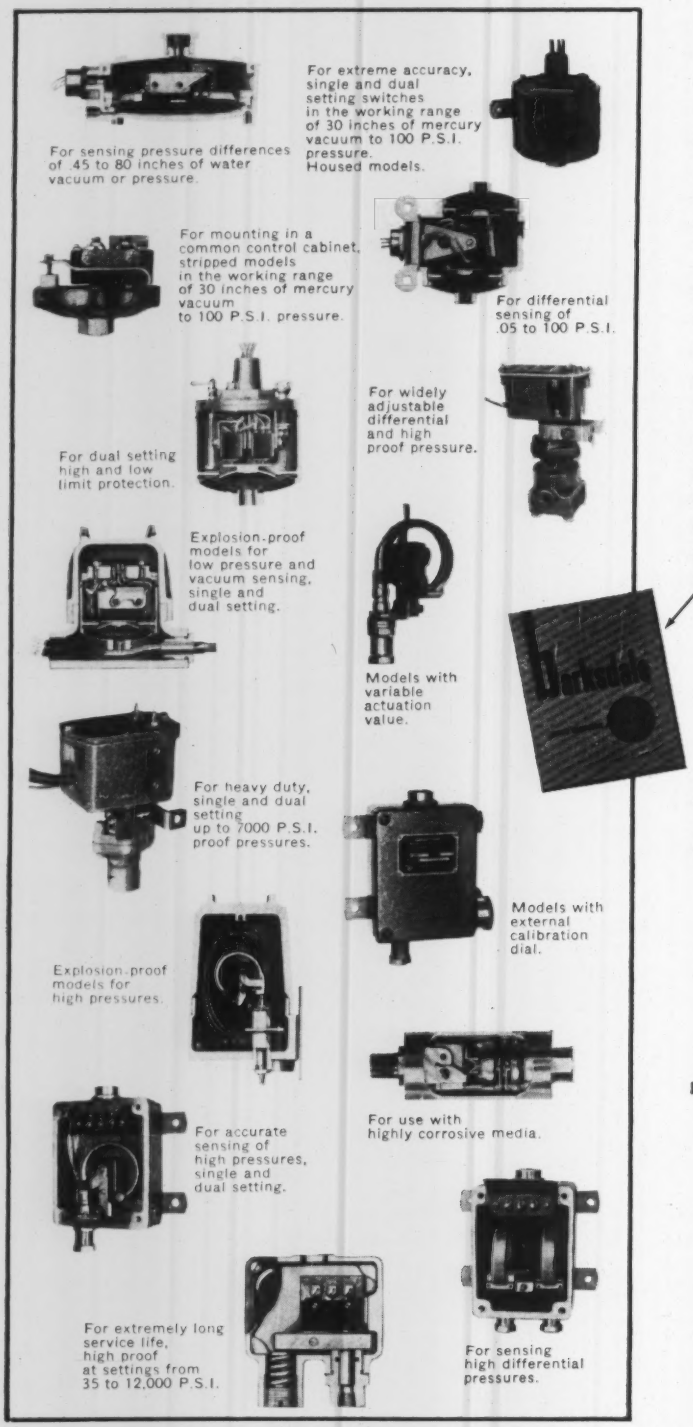
INSTRUMENT DIVISION

Mine Safety Appliances Company

Pittsburgh 8, Pennsylvania

For more information circle **48** on inquiry card.

HERE'S HOW YOU CAN SAVE MONEY ON PRESSURE SWITCHES FOR YOUR SPECIAL REQUIREMENTS...


For sensing pressure differences of .45 to 80 inches of water vacuum or pressure.
For extreme accuracy, single and dual setting switches in the working range of 30 inches of mercury vacuum to 100 P.S.I. pressure. Housed models.
For mounting in a common control cabinet, stripped models in the working range of 30 inches of mercury vacuum to 100 P.S.I. pressure.
For differential sensing of .05 to 100 P.S.I.
For dual setting high and low limit protection.
For widely adjustable differential and high proof pressure.
Explosion-proof models for low pressure and vacuum sensing, single and dual setting.
Models with variable actuation value.
For heavy duty, single and dual setting up to 7000 P.S.I. proof pressures.
Models with external calibration dial.
Explosion-proof models for high pressures.
For use with highly corrosive media.
For accurate sensing of high pressures, single and dual setting.
For extremely long service life, high proof at settings from 35 to 12,000 P.S.I.
For sensing high differential pressures.

If you feel that the pressure switch for your application has to be tailor-made to your requirements, we can offer you the know-how, the experience and probably considerable savings in the bargain.

The know-how is available to you in the form of an engineering and production facility entirely specialized on the design and manufacture of pressure switches. Ask to see the 20-minute sound movie, "The Meletron Story."

The experience we can offer you has been put to the test in every conceivable type of industrial pressure switch application. Ask our representative in your area to show you applications resembling your own.

The savings you can make will be apparent when you consider that there are over six hundred pressure switches listed in our catalog. Even if you should require a special pressure switch, the major components are already in production. Ask for the latest pressure switch handbook and catalog.

PRESSURE SWITCH DIVISION

Barksdale valves

5125 ALCOA AVENUE • LOS ANGELES 58 • CALIF.

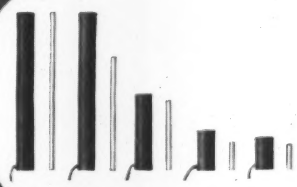
THERE IS A BARKSDALE REPRESENTATIVE IN YOUR AREA:

Alabama, Birmingham	Missouri, Kansas City
Arizona, Phoenix	St. Louis
California, Los Angeles	Nebraska, Omaha
San Diego	New Jersey, Neptune
San Francisco	New York, Buffalo
Colorado, Denver	New York
Connecticut, Wethersfield	Rochester
Dist. of Columbia, Washington	Syracuse
Florida, Miami	North Carolina, Charlotte
Georgia, Atlanta	Ohio, Cincinnati
Illinois, Chicago	Cleveland
Rockford	Dayton
Indiana, Indianapolis	Oklahoma, Tulsa
Kansas, Wichita	Oregon, Portland
Kentucky, Louisville	Pennsylvania, Abington
Louisiana, New Orleans	Pittsburgh
Maryland, Baltimore	Tennessee, Memphis
Massachusetts, Newton	Texas, Houston
Michigan, Detroit	Washington, Mercer Island
Minnesota, Minneapolis	Wisconsin, Milwaukee

For more information circle **49** on inquiry card.

SANBORN *Transducers*

FOR LINEAR MEASUREMENTS...



DISPLACEMENT

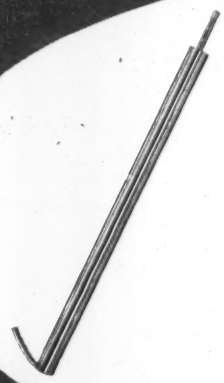
LINEARSYN Differential Transformers

Six series of Sanborn Linearsyns — three of the shielded type, three unshielded — are available, with five models in each series. Linearity is better than 1% of full scale output in all models. Temperature range is from −50° to 205°F.
Special design features include coil assemblies hermetically sealed in epoxy, laminated phenolic jackets (unshielded types) or heavy plated steel jackets (shielded types), improved lead wire strain relief, high permeability alloy cores. Models with axial leads are also available on special order. Within each series all models have identical diameters, tap sizes, lead wires; only the lengths of coil assemblies and cores vary.

Typical Linearsyn Characteristics

Series* (Unshielded)	(Shielded)	Strokes* (±Inches)	Freq. Ranges	Sensitivities* (Volts/inch per volt of excitation at std. carrier freq.)
575DT	585DT	.050 - 1.00	400 cps - 10 kc	56 - 3.70
576DT	586DT	.050 - 1.00	60 cps - 400 cps	70 - 90
590DT	595DT	.005 - .100	400 cps - 20 kc	1.60 - 2.60

*Maximum and minimum values available within each series; data on individual models on request.



VELOCITY

LVsyn Velocity Transducers

LVsyn pickups may be used to measure *linear velocity* directly, *displacement* with a simple integrating circuit, or *acceleration* with a differentiating circuit. There are twenty-four models, all self-generating with shielded cylindrical coil assemblies and high coercive force permanent magnets. Twelve models use regular magnet cores; twelve have *non-breakable* magnet cores. Characteristics of the two groups are the same except for output sensitivity, core length and weight. Features include high sensitivity, single-ended or push-pull output, accurate and stable calibration, unlimited resolution, wide range of sensitivities and sizes, temperature range of −50° to 200°F. They can be immersed in hydraulic fluid. No mechanical connection between coil and core permits low friction level. End stops or displacement limits not needed; undamaged if limits are extended.

Typical LVsyn Characteristics

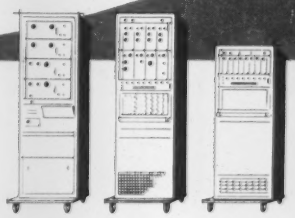
Model	Displacement: Nominal Working Range (Inches)	Displacement: Maximum Usable Stroke (Inches)	Electrical Characteristics: Voltage Output mv/inch	Electrical Characteristics: Total Impedance Series Connection R ohms	Electrical Characteristics: Total Impedance Series Connection L henrys
3LVA5*	0.50	1.30	120	2,000	0.085
6LV2*	2.0	3.4	500	19,000	2.4
6LV2 N	2.0	3.4	250	19,000	2.4
7LV9*	9.0	11.0	350	17,000	2.8

*Four of the twenty-four models available, selected to show minimum, approximate mid-range and maximum working ranges as well as the difference in sensitivity between a regular magnet core model (6LV2) and a non-breakable magnet core model (6LV2 N).

NEW!

COMPLETE DISPLACEMENT TRANSDUCER

"Probe" style, uses differential transformer. With cable and adapter for connection to Sanborn 150, 350 Series Carrier Amplifiers. Stroke ±0.070", high sensitivity, linearity 0.5%, infinite resolution, contact pressure as low as 10 grams. Stainless steel body, carbide tipped contact rod, jeweled bearings. Two models: 580—plug-in cable, flange mounting; 581—miniature, integral cable.



for MULTI-CHANNEL RECORDING

Sanborn direct writing systems now include 1- to 8-channel "150" Series, with a choice of 12 plug-in Preamplifiers; new single-cabinet, compact 6- and 8-channel "350" and "850" Series with interchangeable Preamplifiers, flush-front recorder with electrical pushbutton chart speed control and transistorized Power Amplifiers, and numerous features for high reliability and operating convenience.

For complete facts, call your local Sanborn Industrial Sales-Engineering Representative or write the Industrial Division in Waltham.

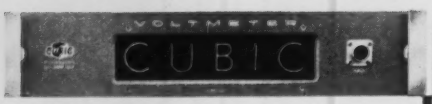
(All data subject to change without notice)

SANBORN COMPANY

Industrial Division

175 Wyman Street, Waltham 54, Mass.

For more information circle **50** on inquiry card.



The Difference is in the Quality

Four and Five-Digit Transistorized

DC VOLTAGE INSTRUMENTATION

For Rapid, Precise Voltage Measurement

Designed for Versatility
Engineered for Reliability
Precision Built, yet Rugged
Easy to Use, Easy to Maintain

NOT JUST A 'VOLTMETER' . . .

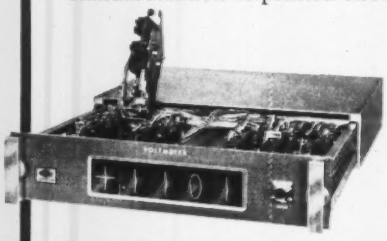
. . . this superior Cubic instrument can measure with great accuracy every phenomenon of science which can be converted to a usable DC voltage level . . . pressure, temperature, depth, volume, salinity, etc. Great economy can be effected through use of the Digital Voltmeter in applications which require precise, legible readings to the unskilled worker without danger of costly operator error. Outstanding engineering and design talents have been combined to produce this fine DC Voltmeter, the most reliable Digital instrumentation available today.

SPECIFICATIONS

Available with 4 digit (Model V-41) or 5 digit (Model V-51) display, the Digital Voltmeter is powered by Control Unit Model C-1, which includes a power supply, precision reference and differential amplifier, and which, separately housed, supplies power to as many units as are required in a Digital System. The Cubic Voltmeter provides an accuracy of .01% plus or minus 1 digit, between ±.0001V and ±999.9V (Model V-41) and ±0.0001V and ±999.99V (Model V-51). Low level voltages ±10 microvolts may be measured by the addition of the Preamplifier unit, Model PA-1.

THE SUPERIOR DIGITAL INSTRUMENT

Space Age know-how that goes into Cubic Corporation's missile tracking systems is also an important engineering and production component of Cubic DC Voltage instrumentation. The 4-digit and 5-digit Voltmeters, powered by the Cubic Control Unit, offer such quality features as unit plug-in construction, a precise two-part filter that eliminates the effect of AC ripple on DC readings, shock-mounted stepping switches with "controlled drive," in which the switch turns off the drive circuit part way through its cycle, ending overdrive and eliminating impact wear. Clear visual display is provided by an ultra-brilliant, edge-lighted read-out containing in-line numerals one inch high. Transistorization ends warm-up time, lengthens instrument life. Cubic's attention to fine detail increases the precision, reliability and functional capability of each instrument and at the same time provides such outstanding features of standardization as printed circuit boards that are interchangeable and stepping switches that swing up and out for ease of routine maintenance. Cubic quality is your guarantee of truly fine instrumentation.



Unit construction of the Cubic Voltmeter and other Digital instruments provides maximum flexibility in creating "systems that design themselves." Inter-*case* wiring and standard-size plug-in units make every Cubic System a customized system using standard units. "Building Block" units which can be added easily to increase systems capabilities are the DC Preamplifier, AC-DC Converter, Digital Ohmmeter, Ratiometer, Master and Auxiliary Scanners and Printer Control Units. Write today for further information.

CUBIC CORPORATION
5575 Kearny Villa Road, San Diego 11, Calif.

CUBIC
ELECTRONIC ENGINEERING WITH A DIMENSION FOR THE FUTURE

For more information circle **51** on inquiry card.

events

March 2-6

Tenth Pittsburgh Conference on Analytical Chemistry and Applied Spectroscopy, Penn-Sheraton Hotel, Pittsburgh, Penna. For information write Fritz Will, Alcoa Research Laboratories, New Kensington, Penna.

March 3-5

Western Joint Computer Conference, IRE, AIEE, and ACM, Fairmont Hotel, San Francisco, Calif., Dr. Robert R. Johnson, Chairman, Write Box 381, Station A., Palo Alto, Calif.

March 11-12

Ninth Conference on Instrumentation for the Iron & Steel Industry, Hotel Roosevelt, Pittsburgh, Penna. For information write Robert Blackwell, Hagan Chemicals & Controls, Inc., P.O. Box 1346, Pittsburgh 30, Penna.

March 18-20

Twenty-Second Annual Short Course for Superintendents and Operators of Water and Sewerage Systems, on campus of Louisiana State University. For information write Fred H. Dean, Louisiana State University, Baton Rouge 3, Louisiana.

March 23-26

I.R.E. National Convention, New York Coliseum & Waldorf-Astoria Hotel, N. Y. For information write W. C. Copp, IRE Adv. Dept., 72 W. 45th St., N. Y. 36, N. Y.

March 26

Fifteenth Annual Quality Control Clinic, Rochester Society for Quality Control, University of Rochester, N. Y. Write Earl D. Hogan, Eastman Kodak Co., Kodak Park Works, Eng. Div., Bldg 23, Rochester 4, N. Y.

April 14-15

Conference on Industrial Instrumentation and Control, Illinois Institute Of Technology, Chicago, Ill. For information write R. W. Bull, Illinois Institute of Technology, 35 West 33rd St., Chicago 16, Ill.

April 20-22

Fifth Annual Southeastern ISA Conference and Instrument Show, Gatlinburg, Tennessee. For information write C. S. Lisser, 203 Virginia Rd., Oak Ridge, Tenn.

May 6-8

1959 Electronic Components Conference, IRE, EIA, AIEE and WCEMA, Benjamin Franklin Hotel, Philadelphia, Pa. Write Bernard F. Osbahr Electronic Industries, Chestnut & 56th Sts., Philadelphia 39, Pa.

November 16-20

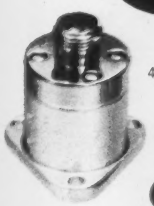
Fifth International Automation Exposition, The New York Trade Show Building, 500 Eighth Ave., New York City. For information write Richard Rimbach Associates, Mgmt., 845 Ridge Ave., Pittsburgh 12, Penna.

when vibration is your problem

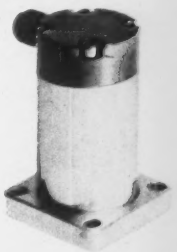
...choose one of these reliable pickups

CEC's seismic-type transducers are recognized for their dependability in such applications as monitoring jet-engine vibration, missile static tests, and analysis of machine-tool vibration. Among the complete line are these representative types:

4-102-A



4-118



4-123

4-102A For vibrations in the 8- to 700-cps range, amplitudes to 2 inches. Weighs 10 oz. Temperature range is 0° to 150°F. See Bulletin 1546-X3.

4-118 Weighs less than 1.5 oz. Measures vibrations from 50 to 500 cps at amplitudes up to 0.12 inch. Usable from −65° to +500°F. Bulletin 1535-X28.

4-123 Economical and rugged, with constant damping from −65° to +500°F. Omnidirectional, operates from 45 to 2000 cps. Weighs only 4.25 oz. Bulletin 1596-X7.

Call your nearest CEC sales and service office about these pickups, or write for the listed Bulletins and our new General Catalog, CEC 1308-X3.

Transducer Division CEC

CONSOLIDATED ELECTRODYNAMICS / 300 n. sierra madre villa, pasadena, california

FOR EMPLOYMENT OPPORTUNITIES WITH THIS PROGRESSIVE COMPANY, WRITE DIRECTOR OF PERSONNEL

For more information circle **52** on inquiry card.

How to get maximum combustion efficiency . . . measure both combustibles and oxygen

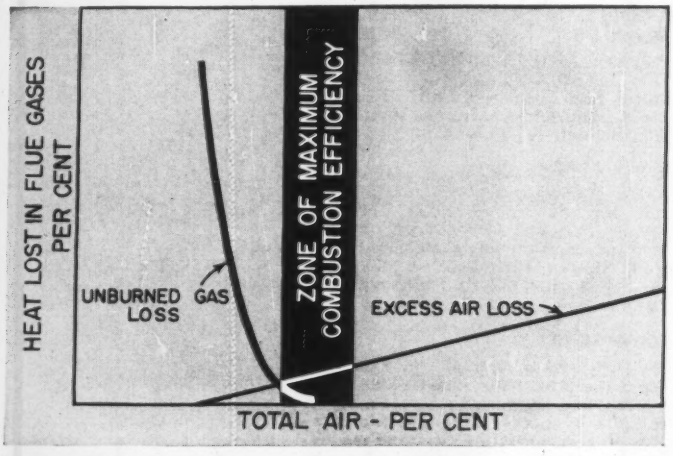
Simultaneous measurement of both oxygen and combustibles is needed to obtain optimum combustion. No instrument that measures only one of these two interdependable factors can give you the full information necessary.

Now, Bailey offers two units, each giving a continuous and simultaneous double check on combustion efficiency: a permanent analyzer-recorder which records both factors on a single chart; and a new light weight, portable unit which indicates both factors.

Both instruments measure: (1) excess air—regardless of the fuel or combinations of fuel being burned, (2) mixing efficiency of your fuel burning equipment by showing per cent combustibles in the flue gas.

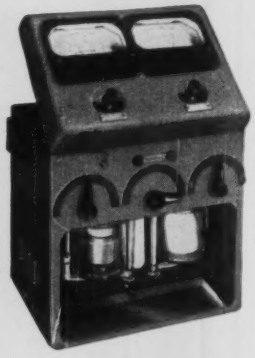
Both units are designed to increase efficiency in the furnace operations of the steel industry, on glass tanks, cement and lime kilns, ceramic and refractory kilns, steam boilers and also on direct and indirect-fired furnaces in the metal processing industries.

To prevent your money from becoming waste gas, look into these two efficiency provers. A Bailey engineer will be glad to give you details or write us for product specifications.


HEAT LOST IN FLUE GASES PER CENT
UNBURNED GAS LOSS
ZONE OF MAXIMUM COMBUSTION EFFICIENCY
EXCESS AIR LOSS
TOTAL AIR - PER CENT

Maximum Combustion Efficiency is secured by keeping the sum of Excess Air Loss and Unburned Gas Loss to a minimum. To do so by the direct method simply measure both oxygen and combustibles in flue gas.

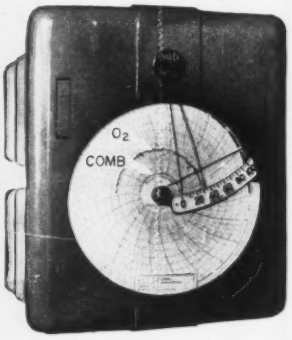
For portable use—
HEAT PROVER Analyzer



The famous Cities Service HEAT PROVER analyzer is now Bailey built and sold. Weighing only 25 pounds, it is a self-contained automatic analyzer including a sampling tip and hose plus a thermocouple for temperature measurement.

Instrument dials are dual range for greater accuracy and sensitivity.

For permanent installation
Oxygen-Combustibles Recorder



The Bailey Oxygen-Combustibles Analyzer-Recorder coordinates both records on one chart. These records enable the operator to keep fuel burning equipment performing continuously in the zone of maximum combustion efficiency. Excess air may be reduced to the point where combustibles begin to show.

G 40-1

Instruments and controls for power and process

BAILEY METER COMPANY

1041 IVANHOE ROAD • CLEVELAND 10, OHIO

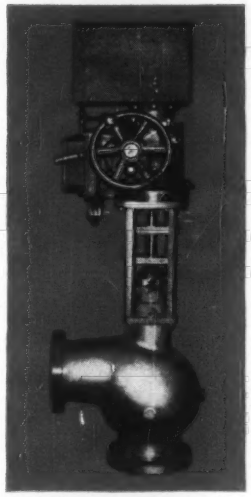
In Canada—Bailey Meter Company Limited, Montreal

BAILEY METERS

For more information circle **53** on inquiry card.

CONTROL VALVES BY CONOFLOW

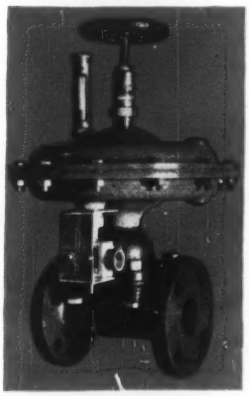
YEARS AHEAD IN DESIGN



SERIES S CONTROL VALVES

Specifically designed to handle the tough services which cause ordinary valves to fail.

- Sizes to 14", pressure ratings to 2500 lbs.
- Extra heavy body construction exceeds ASA standards.
- Self-sealing bonnet will not leak regardless of temperature or pressure conditions.
- Patented Rotomotor actuator handles large sizes with high power requirements.



SERIES HB SAUNDERS VALVES

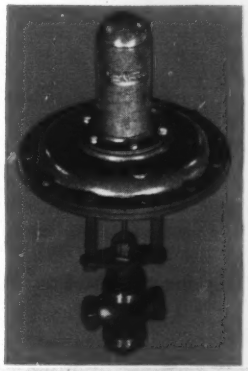
Original close-coupled design introduced by Conoflow has long been an industry standard.

- Completely engineered factory assemblies assure premium performance.
- Actuators for on-off or throttling control in all valve sizes.
- Exclusive Bonnet Loading System available for higher thrust outputs.
- Compact construction allows for more economical piping arrangements.

SERIES LB CONTROL VALVES

Quality construction and truly integrated body-actuator design completely outmodes conventional control valves.

- Cono J Positioner sets new industry standards for precise proportional positioning.
- Rugged cylinder actuator utilizes sturdy metal piston and exclusive lipseals which cannot leak.
- Single-seat body design guarantees positive, tight shut-off under any conditions.
- "Lift-out" seat ring can be replaced quickly with a minimum of effort.
- Extra thick body walls give added protection against corrosion and erosion.
- Simplified construction means less replacement parts and substantial inventory savings.



SERIES AB CONTROL VALVES

A line of economical control valves for handling small flows.

- Bodies available in two and three-way design, in all alloys.
- Extra long stroke; double that of conventional valves.
- Suitable for high pressures and corrosive services.
- Completely enclosed spring-over-diaphragm construction is compact and protects spring from atmospheric corrosion.

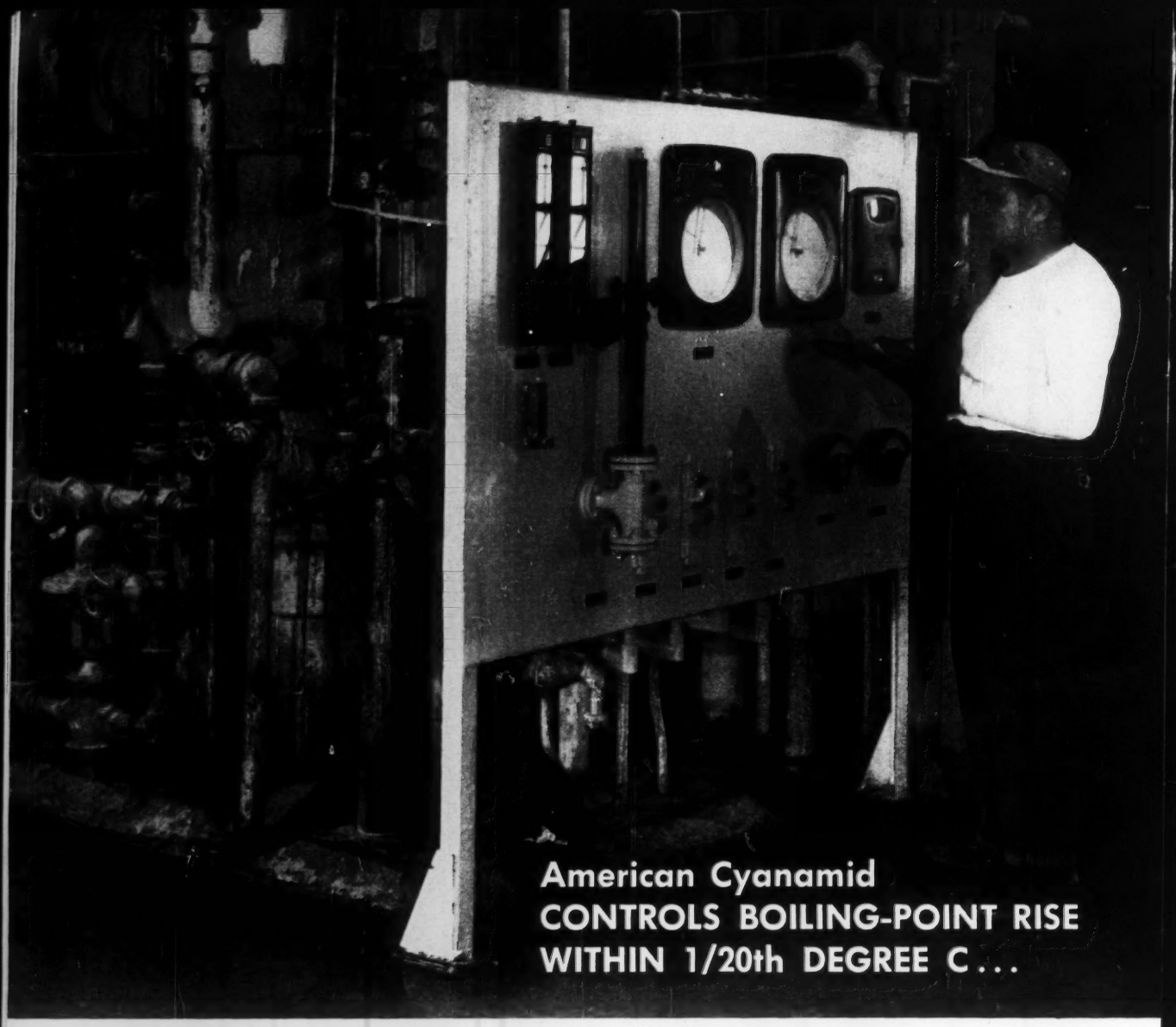
When you specify Conoflow control valves you get the best valve available for your control application. Write for literature or let us put you in touch with a Conoflow representative qualified to help solve your control problems. Conoflow Corporation, Dept. C-805, 2100 Arch Street, Philadelphia 3, Pa.

Cono Controls®

CONOFLOW CORPORATION

FOREMOST IN FINAL CONTROL ELEMENTS

For more information circle **54** on inquiry card.



by unique narrow-span DYNALOG* Electronic Controller

Temperature difference control within ½ of 0.1°C — that's what American Cyanamid demands for process evaporators at their Organic Chemicals Plant in Bound Brook, New Jersey. Boiling-point rise must be held at 108.5°C, since even slight variations affect product quality.

A Foxboro Dynalog Recorder-Controller, with full-scale span of only 5°C, provides the close control American Cyanamid requires. Control is held continuously within 1/20th of a degree of set point — with chart records for proof.

Cyanamid's Narrow Span Controller was installed in 1955. It's been running continuously ever since, virtually unattended. The only servicing or maintenance required on the Dynalog has been re-inking and chart changing.

Get the complete story on the exclusive Dynalog Controller, with full-scale spans as narrow as 5°F — the narrowest span available to industry today! Write for Bulletin 20-10. **The Foxboro Company, 461 Neponset Ave., Foxboro, Mass.** *Reg. U. S. Pat. Off.*

FOXBORO
REG. U.S. PAT. OFF.

DYNALOG ELECTRONIC INSTRUMENTS

For more information circle **55** on inquiry card.

book reviews

Terms and Definition for the Weighing Industry, Scale Mfrs. Association, Inc., One Thomas Circle, Washington 5, D. C., 102 pages, $1.00. Prepared by the Association's Terminology Committee. This dictionary contains 1170 terms peculiar to scales and weighing.

Process Dynamics by Donald P. Campbell, [c 1958] John Wiley & Sons, Inc., 440 Fourth Ave., New York 16, N. Y. 316 pages + xix, $10.50, clothbound, 9¼" x 6¼". Posthumous publication was two years in preparation, and author had revisions and extensions in mind. Book provides a practical approach to problems in automatic process control, also considers the use of linear network theory as a means of predicting the dynamic performance of a plant before it is built.

The Exploration of Time, R. N. C. Bowen. 144 pages, cloth-bound, $6.00, Philosophical Library, Inc., 15 E. 40th St., N. Y. Beginning with the earth as a planet, this book covers astronomical, botanical, zoological, geographical, archeological, anthropological, meteorological, nucleonic and other ways of arriving at the age of earth and man. Includes "the nature of time."

Information Systems in Documentation, edited by J. H. Shera, A. Kent and J. W. Perry, 1957. Interscience Publishers, New York 1, N. Y. 639 p. $12. 9¼ in. Papers by various authors, dealing chiefly with searching for information in print by using punched cards, accounting or statistical machines, and computing devices.

Notes on Analog-Digital Conversion Techniques, edited by Alfred K. Susskind. 1957. Technology Press, Massachusetts Institute of Technology, Cambridge 39, Mass. various paging, unbound. $10. 9 in. Includes (1) systems that influence the specifications for analog-to-digital and digital-to-analog conversion devices; (2) analysis and evaluation of various conversion devices, (3) a "case study."

Nuclear Chemical Engineering, by Manson Benedict and Thomas H. Pigford. 1957. McGraw-Hill Book Co., New York 36, N. Y. 594 p. $9.50. 9¼ in. The first comprehensive treatment of the materials utilized in nuclear reactors, and the recently developed processes for concentrating, purifying and separating these materials.

jamesbury
Double-Value
"Double-Seal"™ Ball Valves

¾" Jamesbury High Pressure Valve in use at Goodyear Tire & Rubber Company, Akron, Ohio, on 3,000 P.S.I. Water Service at Ambient Temperature.

Double EFFICIENCY

In the high pressure water service installation shown here, and wherever the Jamesbury "Double-Seal" principal is employed, there is double the efficiency of performance.

In Pipe Sizes ¼" to 8" for:

High-Pressure service
High-Vacuum service
Handling of hazardous fluids
Cryogenic operations

Distributors In Principal Cities Get The Complete Facts On The Jamesbury "Ball Valve" Principal.

534-8

Name..... Title.....

Company.....

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City..... State.....

☐ Jamesbury Literature
☐ Distributor Service

JAMESBURY CORP., 115 NEW STREET, WORCESTER, MASS.

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MS (STANDARD)

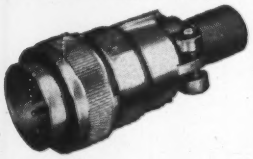
For Aircraft, Electronic Instruments, Military, Industrial, and Commercial Applications

Standard MS-A, MS-B, MS-C... meet Specification MIL-C-5015C. **Plastic inserts.** 15 diameters, 260 insert layouts, 6 shell styles. MS3100 to MS3108 with all accessories. Interchangeability an outstanding feature. Many type assemblies directly available through distributors.

connect with CANNON PLUGS

MS-E (INT. AN-M)

Where Vibration Resistance and Moisture Proofing Are Needed

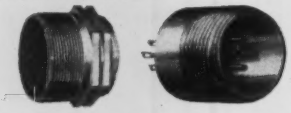


MS-E Series... environment resisting. Meets Specification MIL-C-5015C. Resilient inserts. Completely sealed from cable to cable. Integral clamp and bushing. Grounding lugs. Interfacial sealing with grommet and grommet follower.

The "MS" and associated series connectors offer the

GS (HERMETICALLY-SEALED)

For Use Under Critical Pressure Conditions



Hermetically sealed connectors... with steel shells and contacts to withstand high pressures. Available in GS (MS type), KH, RKH, U, BFH, TBFH. Insulation is Canseal glass material, fused under high temperature to shell and contacts... giving *true hermetic sealing* when soldered or brazed to housing.

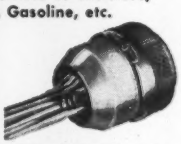
STEEL SHELL FIREWALL

For Open Flame Protection Wherever High Temperatures Are Involved

MS-K and Cannon FW Firewall Connectors... offer you the greatest variety of this type of connector. Cannon made the first firewall connector and continues the leader in the field. Wall—or box-mounting receptacles. Straight or angle 90° plugs. Crimp-on contacts. Inserts of asbestos-filled or glass-filled materials.

CONNECTORS SUITABLE FOR **POTTING**

For Resistance to Moisture, Fuel Oil, Gasoline, etc.



CA06 and CA3106 Types... developed for the Bu Aer Standard MS3106 type minus the end bell. Special plastic "cups" supplied for use as a mold while potting the rear of the connector. Weight saving. Grounding means available. Plastic or resilient inserts.

widest selection of types for all applications to Spec. "MIL"

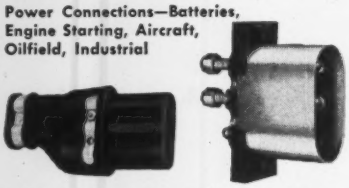
AF, F (VIBRATION PROOF)

For Points of High Vibration Where Extra Strength Is Needed

Vibration Proof CA310*F Solid Shell, Resilient Insert Connectors... Feature extra strong coupling nuts... in hex, spline, knurled types for airline use. In wall—or box mounting, cord-connecting type receptacles. Straight or angle 90° plugs.

AN EXTERNAL POWER

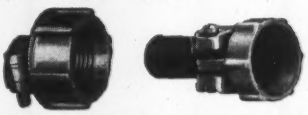
Power Connections—Batteries, Engine Starting, Aircraft, Oilfield, Industrial



CA2551, AN2552, AN3114 and Other Cannon Types Offer Most Complete and Varied Line... in single, double, and three contact fittings. Really rugged! Designed and built for safe, positive connection and long-lasting service.

MS ACCESSORIES

Cable Clamps, Conduit Fittings, Dummy Receptacles, Junction Shells, Dust Caps, Bonding Rings, Bushings, Adapters

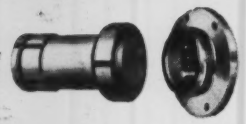


Featuring High-Quality Materials and Workmanship... including AN3057, AN-3057A, AN3420, AN3054, AN3055, AN30-56, AN3058, AN3064, AN3066, AN3068, AN3111, 2120, 2245, 17530, 2209, 2182. Adaptable to all makes of MS connectors.

Cannon Plugs—standard of quality for the industry

W

For Underwater and Severe Moisture Conditions



W Waterproof Series... used underwater and on equipment operating in swamps, rivers, lakes, with underground cables—wherever conditions require thoroughly sealed fittings. Exceptionally rugged. MS type inserts. Acme threads on coupling nuts. Special rubber sealing ring. Special heavy duty cable clamp available.

OTHER SERIES... Audio Types–External Power Connectors–Switching Types–dc Solenoids–Guided Missile Launching Connectors–Miniatures and Sub-Miniatures.

Write Today for new, completely revised, up-to-date MS/AN bulletin!

Since 1915

Please Refer to this Magazine or to Dept. 419

CANNON PLUGS

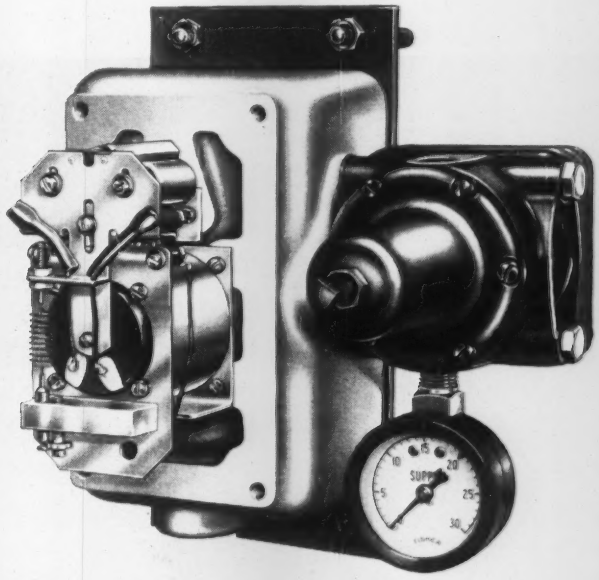
Where Reliability for Your Product Is Our Constant Goal

CANNON ELECTRIC CO., 3208 Humboldt St., Los Angeles 31, Calif. Factories in Los Angeles; Salem, Mass.; Toronto, Canada; London, England; Melbourne, Australia. Manufacturing licensees in Paris, France; Tokyo, Japan. Contact our representatives and distributors in all principal cities.

For more information circle **57** on inquiry card.

Ask Your *FISHER/MAN* How To

SPEED THE INPUT SIGNAL to the CONTROL VALVE



FISHER

TYPE 543

ELECTRO PNEUMATIC TRANSDUCER

Available with or without a pneumatic valve positioner

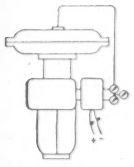
Here's an electro-pneumatic transducer developed for use in electrical control loops where the final control element is pneumatically operated. Explosion proof design makes it ideal for use under hazardous conditions. Input signals may range from 1 to 5 ma. through 10 to 50 ma. . . . output from 3 to 15 psi through 6 to 30 psi. Built-in volume relay permits direct operation of the pneumatic actuator from the Transducer. No extra relays or boosters needed. Relay can be serviced independent of electrical assembly. Unit is completely reversible by reversing input leads and rezeroing.

If you want additional information on the Type 543 Electro-Pneumatic Transducer write Fisher Governor Company.

TYPICAL CIRCUITS		
Input Current	Load Requirements of Controller	Actual Internal Resistance of Transducer
1 to 5 ma dc	3,000 ohms maximum	2,500 ohms ±125 ohms
1 to 5 ma dc	12,000 ohms ± .5%	12,000 ohms ± 50 ohms
10 to 50 ma dc	500 ohms maximum	57 ohms ± 4 ohms

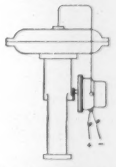
PERFORMANCE DATA	
Linearity	1% of full range
Air Consumption Rate	2 SCFH with 15 psi output pressure
Resolution Sensitivity	.05% of input range
Frequency Response	Complete frequency response data with Fisher topworks available

TYPE 3541



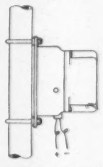
Electro Pneumatic Controller Mounted on Control Valve

TYPE 543



Transducer Mounted on Control Valve

TYPE 543



Transducer Mounted on Stand Pipe

IF IT FLOWS THROUGH PIPE ANYWHERE IN THE WORLD . . . CHANCES ARE IT'S CONTROLLED BY . . .

FISHER GOVERNOR COMPANY

Marshalltown, Iowa / Woodstock, Ontario / London, England

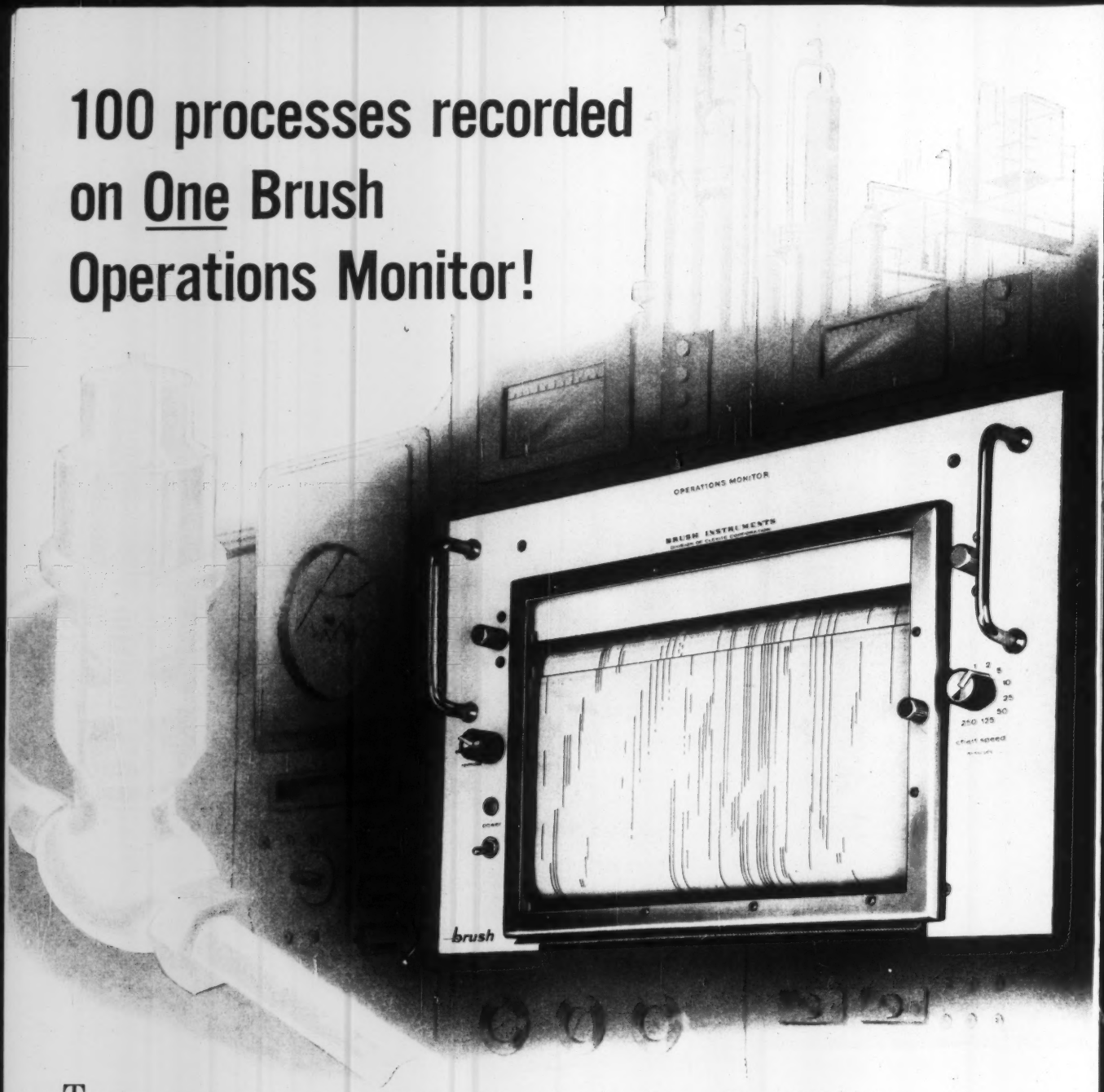
CONTINENTAL EQUIPMENT CO. DIVISION, Coraopolis, Pennsylvania

FISHER® Controls

SINCE 1880

For more information circle **58** on inquiry card.

100 processes recorded on One Brush Operations Monitor!



This compact Brush Operations Monitor can improve the control of power distribution systems, chemical processes and automated production lines.

On a moving chart only 12″ wide, 100 separate operations can be recorded at the same time . . . what happens or doesn't happen . . . monitoring present recording and indicating devices. For example, the opening or closing of a valve . . . the action of a relay . . . the control of motors . . . all are documented in a time relationship to other operations. You get an immediate picture of an *entire situation* at any time. Sixteen different time bases can be selected from remote or on-the-spot locations.

Write to Brush for details. Engineering assistance is available at all Brush factory branches, strategically located throughout the United States.

brush INSTRUMENTS

DIVISION OF

3405 PERKINS AVENUE **CLEVITE** CORPORATION CLEVELAND 14, OHIO

For more information circle **59** on inquiry card.

THE BIG LOOK

IN GENERAL ELECTRIC'S NEW PANEL INSTRUMENTS

DISTINCTIVE APPEARANCE

Clean-line design sparkles with functional new beauty—adds a distinctive touch to your finest switchboards and panels. Big border-to-border scale is framed in aluminum for better color blending. Design innovation creates the illusion of bigness, yet they fit into the same useable space as old style instruments.

EXCELLENT READABILITY

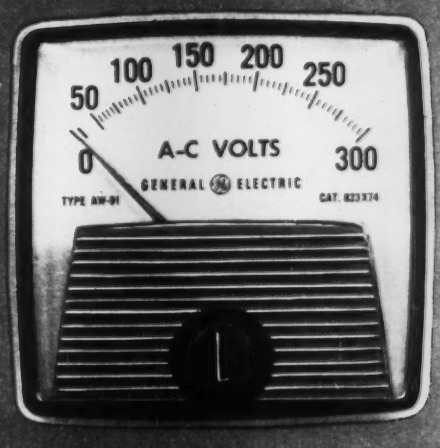
BIG LOOK styling provides up to 28% increase in scale length over types replaced. Easy-to-read numerals cannot be obscured by the slim, tapered pointer. Clear raised window allows natural light to flood scale area, keeping shadows out.

RELIABLE OPERATION

Self-shielding: Exclusive moving-magnet mechanism and the core-magnet mechanism can generally be mounted on magnetic or non-magnetic panels without special calibration.

Completely Sealed: All cases are sealed with neoprene gaskets to protect internal parts from dust, dirt, and water for extra-long, trouble-free operation. D-c movements and a-c iron-vane movement are accurate to within ± 2% of full scale value.

For complete information contact your nearby G-E Apparatus Sales Office or Distributor; or write for bulletin GEA-6678A, Section 582-31, General Electric Company, Schenectady 5, N. Y.



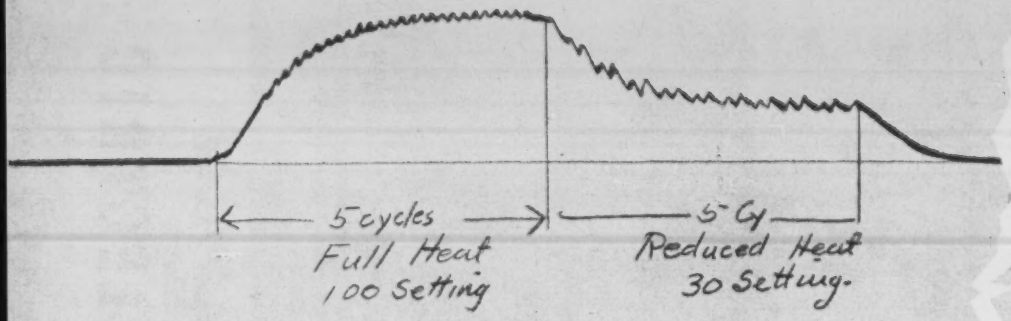
ACTUAL SIZE

Although they look bigger, these a-c and d-c units are actually 2½- and 3½-inch sizes. Mounting is interchangeable with JAN, MIL, and ASA (round) specifications.

Progress Is Our Most Important Product

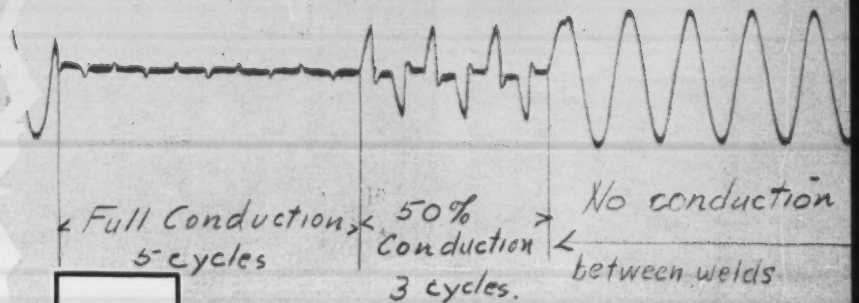
GENERAL ELECTRIC

For more information circle **60** on inquiry card.



Oscillogram of Welding Current Pattern D.C.
Taken from shunt
in lower arm of welder.
(Rectified 3 phase

Shows gradual build-up
and decline of welding current.
Essential in making
good spot welds



Oscillogram taken
across ignitron tubes.

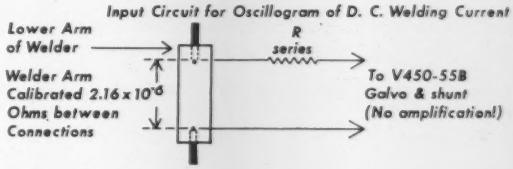
this is a record

These welder phase-shift heat-control patterns were directly recorded with a Honeywell 906 Visicorder at Bristol Aircraft (Western) Limited in Winnipeg.

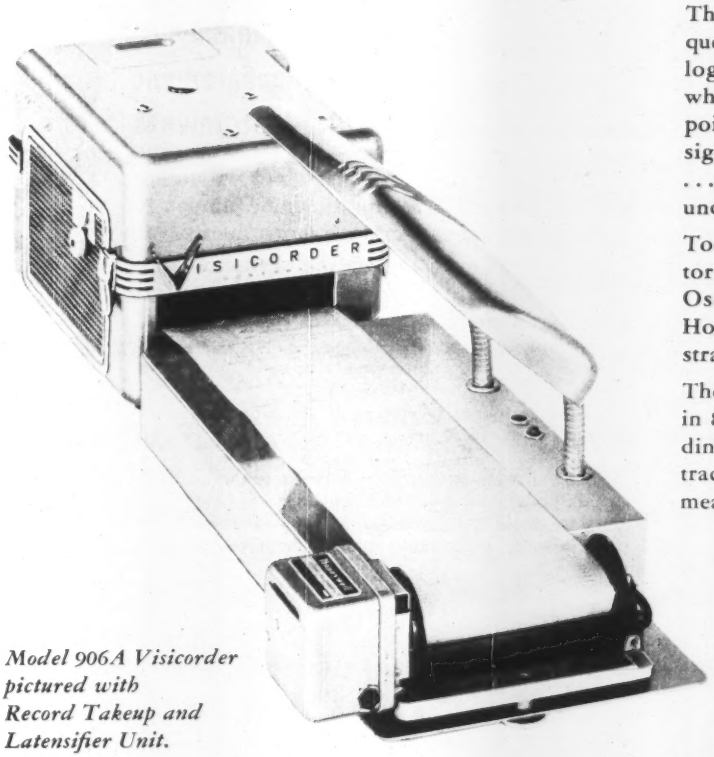
Since the welding heat generated is proportional to the square of the current value, phase shift must be accurately controlled in order to determine the heat value. If the phase shift dial is not accurately calibrated, the result is too much or too little heat, and a poor weld.

In this application, the Visicorder is an essential guide to accurate calibration, since ink-type recorders do not cover the sensitivities and frequencies needed and an oscilloscope would present a continually changing pattern since most recording periods are less than 10 cycles. The directly-recorded Visicorder patterns allow a convenient study of the exact time when the current wave form was being cut off.

Here is the circuit used in this test.


Input Circuit for Oscillogram of D. C. Welding Current
Lower Arm of Welder
R series
Welder Arm Calibrated 2.16 x 10⁻⁶ Ohms between Connections
To V450-55B Galvo & shunt (No amplification!)

# of phase shift



Model 906A Visicorder pictured with Record Takeup and Latensifier Unit.

The Honeywell Visicorder is the first high-frequency, high-sensitivity direct recording oscillograph. In laboratories and in the field everywhere, instantly-readable Visicorder records are pointing the way to new advances in product design, rocketry, computing, control, nucleonics . . . in any field where high speed variables are under study.

To record high frequency variables—and monitor them as they are recorded—use the Visicorder Oscillograph. Call your nearest Minneapolis-Honeywell Industrial Sales Office for a demonstration.

The new Model 906A Visicorder, now available in 8- and 14-channel models, produces longitudinal grid lines simultaneously with the dynamic traces, time lines, and trace identification by means of new Accessory units.

Reference Data: Write for Visicorder Bulletin

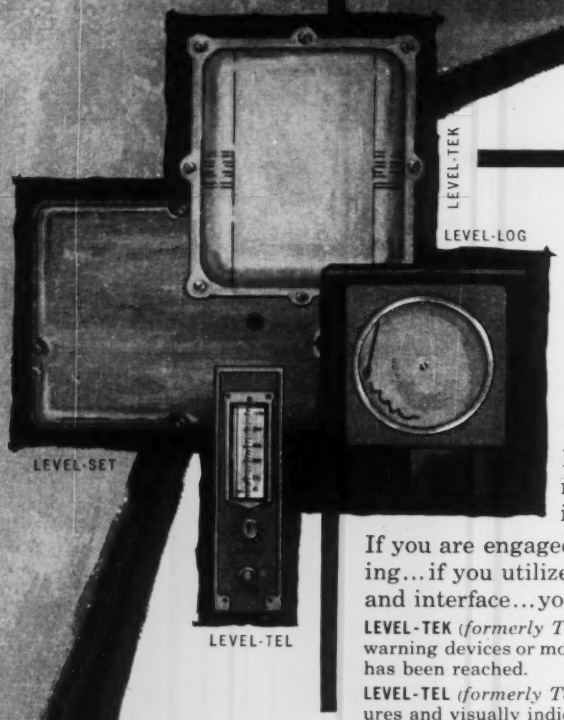
Minneapolis Honeywell Regulator Co.,
Industrial Products Group, Heiland Division
5200 E. Evans Avenue, Denver 22, Colorado

Honeywell

Industrial Products Group

For more information circle 61 on inquiry card.

IMPORTANT ANNOUNCEMENT



New family name for Robertshaw level measurement and control instruments

Effective January 1, 1959, Robertshaw will adopt more uniform and meaningful trade names to identify its line of capacitance instruments.

If you are engaged in mining, refining, processing or manufacturing... if you utilize or encounter liquids, granular solids, powders and interface... you can rely on these time-tested products.

LEVEL-TEK *(formerly Tektor)* — An on-off device which operates local or remote warning devices or motor-driven valves and pumps when a predetermined level has been reached.

LEVEL-TEL *(formerly Telstor)* — A continuous level system which detects, measures and visually indicates changes in media level.

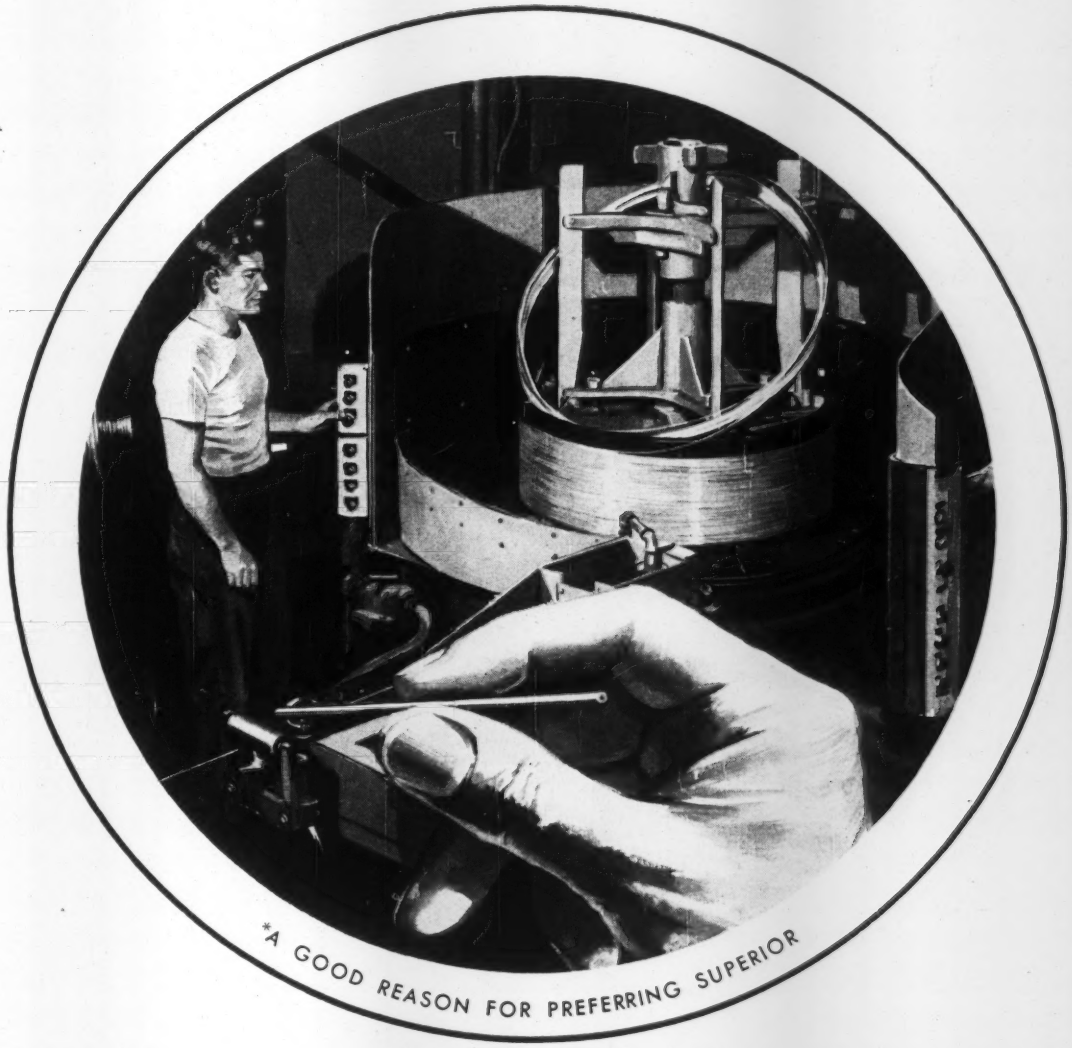
LEVEL-SET *(formerly Pneutronic Level Controller)* — An instrument which converts changes in level to proportional changes in air pressure for maintaining a constant head in vessels where pneumatic feed control systems are employed.

LEVEL-LOG *(formerly Series 42 Recorder-Controller-Indicator)* — A versatile and extremely accurate RF null balance capacitance system for level measurement, recording and control.

AERONAUTICAL AND INSTRUMENT DIVISION

Robertshaw-Fulton CONTROLS COMPANY

SANTA ANA FREEWAY AT EUCLID AVENUE • ANAHEIM, CALIFORNIA



New—capillary tubing in 3000 ft. lengths for industrial instrumentation

***Improved bore uniformity, broader size range, flow tested to your specifications**

To meet the demands of modern instrument design and automated fabrication, Superior is now offering seamless capillary tubing in lengths up to 3000 ft. It is available in nine different materials from select-quality raw stock, including stainless steel, carbon steel, nickel and nickel alloy.

Scrupulous care in manufacture results in a finished product that is bright and scalefree, with an extremely smooth, uniform bore. The tubing is easy to weld, braze or solder. ODs range up to $^{3}/_{16}$ in.—IDs from .004 to .040 in. maximum.

When you order capillary tubing by Superior you are assured that your specifications will be met. In addition to 100% dimensional, pressure and finish inspections, we also can test lengths for flow rates with the latest equipment when specified. Rates can be varied from 5 to 3700 cc per min.

More information on Superior's improved capillary tubing products is yours for the asking. Send coupon today.

Superior Tube

The big name in small tubing

NORRISTOWN, PA.

All analyses .010 in. to ⅜ in. OD—certain analyses in light walls up to 2½ in. OD

West Coast: Pacific Tube Company, 5710 Smithway St., Los Angeles 22, Calif. RAymond 3-1331

SUPERIOR TUBE COMPANY
1968 Germantown Ave., Norristown, Pa.
Send me a copy of new Data Memorandum 11, on capillary tubing.

Name_____ Title_____

Company_____

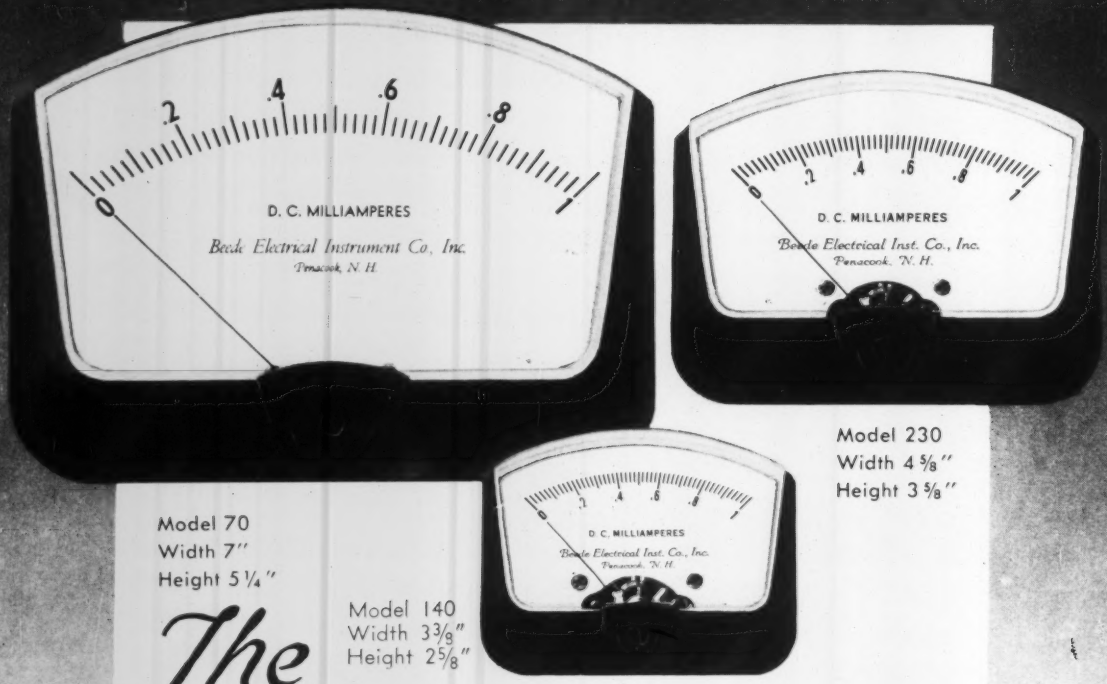
Street_____

City_____ Zone____ State_____

For more information circle **63** on inquiry card.

← Circle **64** on inquiry card.

BEEDE
INDICATING INSTRUMENTS



Model 230
Width 4 5/8"
Height 3 5/8"

Model 70
Width 7"
Height 5 1/4"

Model 140
Width 3 3/8"
Height 2 5/8"

The PANORAMA

Gives you better, clearer vision and longer scales, with easier readability.

The plastic panel provides excellent natural illumination, top, sides and front.

Available frosted or color of your choice.

The ultra modern beauty of the PANORAMA will add much to your product.

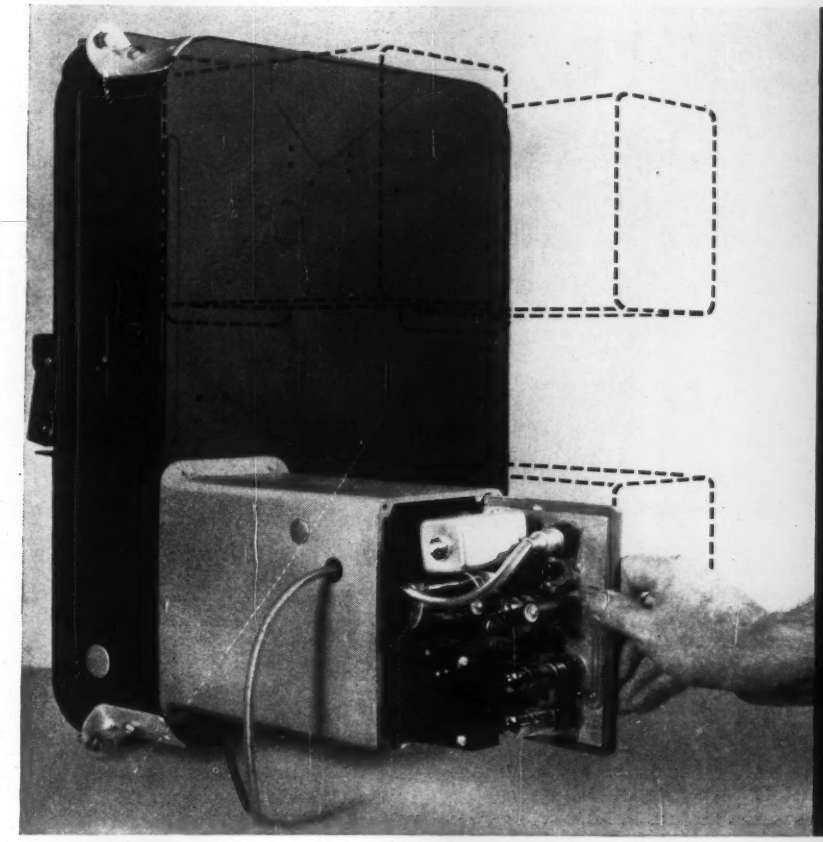
BEEDE ELECTRICAL INSTRUMENT CO., INC.
PENACOOK, NEW HAMPSHIRE

For more information circle **62** on inquiry card.

for economical remote recording of temperature . . .

THE NEW HAGAN TC (THERMOCOUPLE) POWRLOG!

LOW first cost
LOW maintenance cost
LOW parts inventory cost



UNIQUE CONSTRUCTION—same amplifier used for all temperature applications by simply changing plug-in input box.

UP TO FOUR different variables may be recorded on the same chart.

ACCURATE—PowrLog's resolution is 0.1% of full scale, overall instrument accuracy—0.5%.

FAST—with pen driveshaft torque of 45 in./lb., PowrLog achieves full scale pen deflection in 2 seconds.

STABILITY ASSURED—simple adjustment balances gain to resolution, no hunting or dead band problems.

The Hagan model TC (thermocouple) PowrLog receiver provides low cost remote measurement and/or control of temperatures with a high degree of accuracy. The system consists of an amplifier, drive motor and gear train as the basic unit. Associated with this basic unit are a series of plug-in input boxes, one for each type of measurement. Every component part has been selected for reliability, accuracy and long wear characteristics. The net result is the reduction of maintenance costs and problems to a new low.

Since the same high-gain AC amplifier is used in all applications, parts stocking problems are eliminated, with consequent savings in inventory costs.

Write for descriptive bulletin, or ask a Hagan engineer to explain the many specific advantages of the new PowrLog for temperature measurement and other applications.

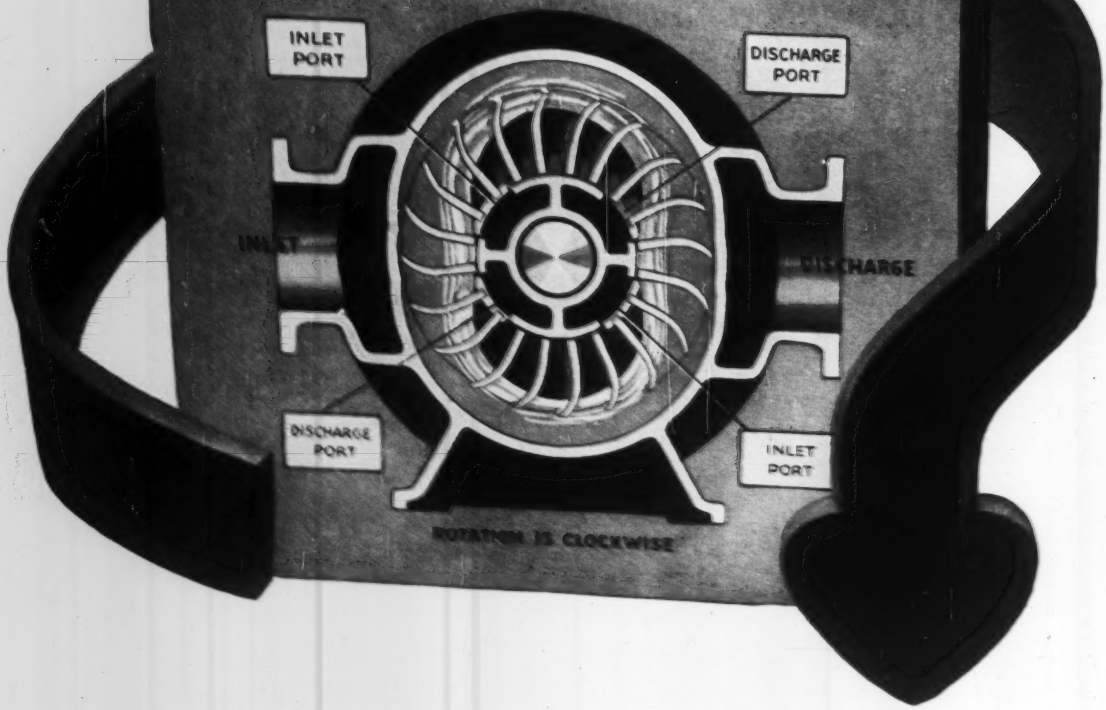
HAGAN CHEMICALS & CONTROLS, INC.

DIVISIONS: CALGON COMPANY, HALL LABORATORIES

HAGAN BUILDING, PITTSBURGH 30, PA.
In Canada: Hagan Corporation (Canada) Limited, Toronto
European Division: Via Flumendosa No. 13, Milano, Italy

For more information circle **65** on inquiry card.

Nash Instrument Air Compressors deliver only clean air, free from oil or dust, and without filters



Here is Why!

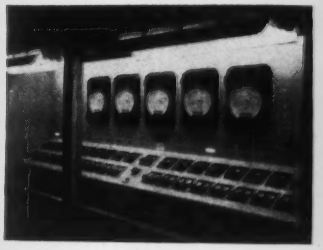
You can dispense with oil filters and dust filters when you install ®Nash® Clean Air Compressors. You can save the cost of maintaining these devices. You can greatly reduce instrument maintenance costs. For the Nash employs no internal lubrication, therefore no troublesome oil is in the delivered air. Moreover, air from a Nash is thoroughly washed and cooled as it passes thru the pump. Dust in the plant atmosphere, even fly ash, is immediately removed.

®Nash® Clean Air Compressors are simple, with only one moving element. No valves, gears, pistons, sliding vanes, or other enemies of long life and constant performance complicate a Nash. No aftercoolers are needed. You will find it profitable to investigate these pumps, now.

- No oil filters.
- No dust filters.
- No internal lubrication to contaminate air handled.
- No internal wearing parts.
- No valves, pistons, or vanes.
- Non-pulsating pressure.
- Original performance constant over a long pump life.
- Low maintenance cost.

NASH ENGINEERING COMPANY
370 WILSON, SO. NORWALK, CONN.

HAGAN NEWSLETTER
Behind the Panel



HOW AUTOMATIC ARE AUTOMATIC CONTROLS?

The answer depends a lot on the reliability factor in the system, and on how well the various control elements are integrated. A great many control systems are designed to operate on full automatic only when the process is within normal operating range. In applications where the process can vary widely, or where operators must be relieved of control supervision during abnormal conditions, true automatic control is desirable. Hagan systems are designed to accomplish this; for example:

OUTDOOR BOILER CONTROL SYSTEM STAYS ON AUTOMATIC DURING GENERATOR TRIP-OUT: a new outdoor utility station in the Southwest experienced a generator trip-out, and in the excitement, the 3-element feed-water control system was left on automatic. Inspection of charts after the difficulty was overcome showed that the feedwater system had maintained proper drum level throughout the two hour shut-down, even though the system went through the complete shut-down, start-up cycle.

SOAKING PITS NEVER OPERATED ON MANUAL CONTROL: on a new installation of two batteries of 3 pits, the heaters are instructed never to operate on manual control. In case of control malfunction, the pits are shut down until the system is repaired. In a year of operation, this policy has resulted in the loss of only four pit hours production time. Pit bottoms have not built up excessively, indicating close control of combustion and absence of ingot washing. (Item A-1)

FIRST SOLID STATE ELECTRONIC BOILER CONTROL SYSTEM

Operational magnetic amplifiers, used as basic control elements in the combustion, feedwater, pump recirculation and steam temperature control systems, will be installed on a new 1,260,000 lb/hr boiler at a Southern utility. The Hagan proposal--for the first solid state electronic boiler control--was selected by the utility in competition with two other electronic systems that did not achieve the reliability inherent in a solid state system. (Item A-2)

ELECTRONIC TEMPERATURE CONTROLLER SENSES 0.000001 VOLT CHANGE

Ultrasensitive, the Hagan PowrAmp Temperature Controller is responsive to thermocouple output fluctuations of one-millionth of a volt. Designed for precise temperature control in situations where either the heater or the product temperature can change rapidly, the Controller provides adjustments for proportional band, reset, and rate action. While this is a new instrument, it has already been proven in action. It was selected for the critical job of controlling glass fiber drawing dies operating at 1600F and it is limiting die temperature fluctuation to less than 0.25F. The Controller provides stepless regulation and will handle up to 330 kva through saturable reactors. (Item A-3)

NEW POWRLOG OFFERS LOW-COST TEMPERATURE MEASUREMENT OR CONTROL

Our systems engineers wanted a rugged, low-cost remote recorder for process measurement in industrial applications. Once we decided that the right way to minimize maintenance was to make use of unitized construction, the acorn we had been asked for rapidly became a full fledged oak. We ended up with an instrument that will measure any function that can be converted into an error voltage, either AC or DC, and then convert these voltages into mechanical movement that may be used for driving a recorder, indicator, integrator, pneumatic transmitter or a controller.

Utilizing a unique amplifier that is adaptable to a wide variety of applications by means of plug-in input boxes, the new HAGAN PowrLog is particularly well suited for the remote measurement and/or control of temperature with either thermocouples or resistance bulb thermometers. The components of this versatile instrument have been selected for accuracy and high reliability--result--maintenance has been reduced to a new low. (Item A-4)

HAGAN CHEMICALS & CONTROLS, INC.
Hagan Building, Pittsburgh 30, Pa.

If you would like more information on any of the above items, check the appropriate box below.

☐ Item A-1 ☐ Item A-2 ☐ Item A-3 ☐ Item A-4

For more information on Item A-1 circle **66** on inquiry card.
For more information on Item A-2 circle **67** on inquiry card.
For more information on Item A-3 circle **68** on inquiry card.
For more information on Item A-4 circle **69** on inquiry card.

Nash Instrument Air Compressors deliver only clean air, free from oil or dust, and without filters
INLET PORT
DISCHARGE PORT
DISCHARGE PORT
INLET PORT
ROTATION IS CLOCKWISE

Here is Why!

You can dispense with oil filters and dust filters when you install ®Nash® Clean Air Compressors. You can save the cost of maintaining these devices. You can greatly reduce instrument maintenance costs. For the Nash employs no internal lubrication, therefore no troublesome oil is in the delivered air. Moreover, air from a Nash is thoroughly washed and cooled as it passes thru the pump. Dust in the plant atmosphere, even fly ash, is immediately removed.

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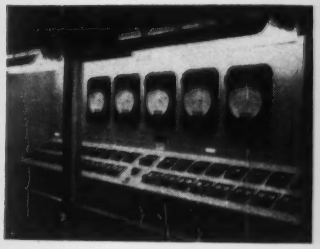
NASH ENGINEERING COMPANY
370 WILSON, SO. NORWALK, CONN.

HAGAN NEWSLETTER
Behind the Panel



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HAGAN CHEMICALS & CONTROLS, INC.
Hagan Building, Pittsburgh 30, Pa.

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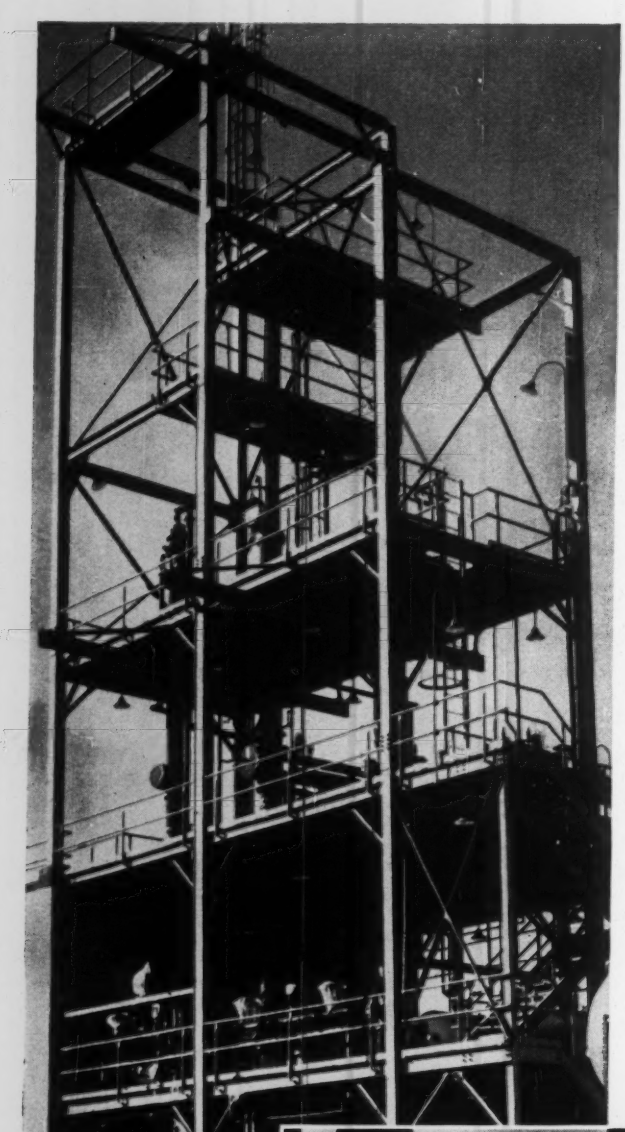
☐ Item A-3 — For more information on Item A-3 circle **68** on inquiry card.

☐ Item A-4 — For more information on Item A-4 circle **69** on inquiry card.



In the control room of Pennsalt's Isotron plant, a process operator checks component variations on a Chromomax Analyzer as a guide to resetting control points.

New

CHROMOMAX*

helps Pennsalt boost product quality

For more than six months, Pennsalt Chemicals Corporation at Calvert City, Ky. has based control of its Isotron plant on Chromomax data. Component concentrations as low as 0.01% are detected and measured by this highly sensitive L&N Chromomax Gas Chromatography Analyzer. It enables Pennsalt's operator to monitor impurity levels every 10 minutes . . . to make any necessary control adjustments. The result: the refrigerants and aerosol propellents produced have a purity of more than 99%.

Pennsalt also relies on Chromomax because it's dependable . . . needs only routine maintenance . . . requires simply a weekly check against a standard sample. The instrument maintenance group finds that programming cycles are easy to reset after a process changeover. These benefits confirm Pennsalt's policy of getting the best instrument for the application.

If you, too, have a process stream measuring problem, let L&N's versatile Chromomax Analyzer solve it . . . economically . . . dependably. If required, your Chromomax can be equipped with dual column switching or electronic integration.

Check with your nearest L&N Office for application details or write to Leeds & Northrup Company, 4955 Stenton Ave., Phila. 44, Pa. for information.

**Trademark*

LEEDS NORTHRUP
Instruments Automatic Controls • Furnaces

For more information circle **70** on inquiry card.

SCIENTIFIC and INDUSTRIAL INSTRUMENT & APPARATUS INDUSTRY

• Outlook for 1959
• Review of 1958

SCIENTIFIC and industrial instrument and apparatus sales during 1959 are expected to rise by 10 to 15% above the estimated 1958 sales of $3.25 billion. Capital investment, to which industrial instrument sales are linked, is expected to show a slight increase, with expenditures by the petroleum, stone, clay, and food and beverage industries offsetting anticipated declines by the ferrous and nonferrous metals industries, and the chemical and the textile industries. Moreover, since the major portion of the overall capital outlays will be devoted to modernization of equipment, a higher ratio of instrument sales per dollar of investment is expected.

Continued emphasis on research and development, especially in the area of astronautics and nuclear power, is expected to result in further increases in laboratory instruments and apparatus, which manifested about an 8% increase during 1958 over 1957. Furthermore, military spending for guided missiles and supporting installations, electronic equipment, and defense warning systems should assist in pushing overall instrument sales to a new high level in 1959.

Trends in 1958

This study is confined to instruments and apparatus designed to measure, test, record and/or control electrical, chemical, and physical quantities. These devices are used in research, engineering, manufacturing, navigation, meteorology, astronomy, surveying, and analogous activities.

The specification immediately excludes from the purview of this study the class of instruments known as "machinists' precision tools" such as calipers, micrometers, gauge blocks, measuring scales, etc.* Also excluded are slide rules, drafting and map reading plotting instruments, templates, and similar items which are subsumed under Standard Industrial Classification industry group 3811: engineering, laboratory, and scientific and research instruments and associated equipment.

Empirical evidence supports the belief that, for example, a million dollar outlay by the chemical or petroleum industries would mean a greater amount of industrial instrument sales than an identical amount spent by the textile industry. To obtain a quantitative concept of the relative differences between various industry groups in this respect, a multiple correlation analysis was conducted between the instrument sales as given in the table and capital spending broken down as follows: 1. chemical industry, 2. petroleum industry, 3. all over manufacturing, 4. public utilities, and 5. all other non-manufacturing. Partial regression coefficients were obtained as a measure of the relative variation in instrument sales that may be attributed to each of these five capital spending groups. These were then compared with the average percent of the aggregate capital investment for which each group was responsible, taken over the 11 year span from 1947 through 1957 inclusive. The results are presented below:

Industry Group	Percent of Instrument Sales	Percent of Total Capital Outlays
Chemical	16.6	4.0
Petroleum	12.5	9.5
Public utilities	13.0	15.1
All other manufacturing	30.4	24.3
All other non-manufacturing	3.8	47.1
Total	76.3	100.0

The foregoing indicates that capital investment in the aggregate is responsible for about 75% of the variation in instrument sales. Although accounting for only about 4% of capital spending on the average, approximately 16% of instrument sales may be attributed to outlays by the chemical industry. At the other extreme, non-manufacturing industries (except public utilities) are responsible for almost half of the capital investment, but only for less than 4% of instrument sales. (For this reason, the "all other non-manufacturing" group was dropped from subsequent analyses and the "all other manufacturing" broken down into durables and non-durables.)

As a bench mark against which the validity of these results could be evaluated, related information was solicited from a representative sample of companies that specialize in designing and constructing industrial plants. The firms were requested to submit data reflecting the ratio of the cost of instrumentation in a plant of a given type to the total cost of the plant. The average of estimated ratios for various types of installations is given below.

Type of Plant	Ratio of Instrument Cost to Total Plant Cost	
	Low	High
Chemical	0.03	0.15
Petroleum	0.02	0.12
Paper and pulp	0.005	0.03
Iron and steel (basic)	0.005	0.035
Rubber products	0.01	0.03
Electric power generating stations	0.01	0.035

*Editor's note: These items are covered by SIC 3545.

Abstracted from U. S. Dept. of Commerce report ER-58-69, B D S A, Scientific, Motion Picture, and Photographic Products Div.

TABLE 1. FEDERAL EXPENDITURES FOR RESEARCH AND DEVELOPMENT, FISCAL YEARS 1948 THROUGH 1958

(Millions of Dollars)

Fiscal Year	Conduct of R & D	Increase of R & D Facilities	Total	% of Total Used for Increase of R & D Facilities
1948	785	91	876	10.4
1949	954	167	1,121	14.9
1950	1,042	202	1,244	16.2
1951	1,522	330	1,852	17.8
1952	1,910	307	2,217	13.8
1953	1,920	248	2,168	11.4
1954	1,999	227	2,226	10.2
1955	2,045	207	2,252	9.2
1956	2,419	273	2,692	10.1
1957*	2,830	527	3,357	15.7
1958*	3,020	356	3,376	10.5

*Estimated.

Source: Federal Funds for Science, National Science Foundation, Volumes III and IV.

TABLE 2. DEPARTMENT OF DEFENSE EXPENDITURES FOR AIRCRAFT, GUIDED MISSILES, AND ELECTRONIC AND COMMUNICATIONS EQUIPMENT, FISCAL YEARS 1951 THROUGH 1958

(Millions of Dollars)

Fiscal Year	Expenditures
1951	2,262
1952	5,594
1953	8,713
1954	9,665
1955	9,391
1956	9,084
1957*	9,218
1958*	9,703

*Estimated.

Source: Department of Defense Expenditures by Major Budget Category, Form EISED-220, Revised January 1957.

The range within the chemical industry reflects the various types of chemical processes prevailing—dry, wet, continuous, etc.

A more reliable indicator of instrument sales is information concerning the expenditures for increasing research and development facilities. Data of this type are not available for private industry from any known published sources. However, the National Science Foundation published data on research and development expenditures by the Federal Government, broken down according to amounts spent respectively for conduct of research and development and for additions to research facilities. These are presented in Table 1 for the span 1948 through 1958 inclusive.

The major portion of those products which incorporate instruments or their mechanisms as components is purchased by the military services. These end items include aircraft, guided missiles and missile launching and monitoring installations, fire control systems, target tracking systems, etc. Of particular interest to this study are the Department of Defense expenditures for aircraft, guided missiles, and electronic and communications equipment, all of which contain a high instrument content in relation to the cost of the end products. The pertinent information is found under Category III of Department of Defense Document EISED-220: "Department of Defense Expenditures by Major Budget Category." The combined yearly totals for the three classes of end items, for 1951 through 1958 inclusive, are given in Table 2.

It is important to note that budgetary information anticipate expenditures in the period for which instrument sales are forecast. Similarly, the Office of Business Economics publishes data which reflect the expectations of the various industries concerning their capital spending for the ensuing year. Thus, three economic indicators are available which indicate the respective amounts for the period for which the projection is being made.

Industrial Instruments. Sales of industrial instruments declined by approximately 13% during the first half of 1958, as compared with the same period for 1957. Capital expenditures by all manufacturing industries decreased by about 25%, but the dip in spending for equipment was only half as large, on a percentage basis, as the drop in outlays for plant structure.

The greatest portion of the decrease in capital spending is attributed to the primary ferrous and nonferrous metals industries. It is important to note that, within each area of specialization in the instrument field, there are even narrower specialized sectors. For example, some manufacturers in the industrial control instrument area confine themselves to servicing the primary metals industries.

Consequently, instrument manufacturers who sell principally to the ferrous and nonferrous metals industries have probably experienced anywhere from a 30% to a 40% drop in new orders during the first half of 1958.

Public utilities have continued to increase capital spending, thereby tending to offset the decreases by the manufacturing industries.

For the second half of 1958, the overall downward trend in capital investment by manufacturing facilities is expected to be arrested with either a leveling off or slight increases being manifested by most industries. The notable exception, as previously mentioned, is the primary ferrous and nonferrous metals group. However the influence of these industries on instrument sales has been offset to a considerable degree by increased spending by the petroleum, chemical, paper and pulp, and other non-durable goods industries.

Consequently, industrial instrument sales during the second half of 1958 should manifest an increase which is expected to bring the total for this year much closer to the 1957 sales level.

Laboratory Instruments and Apparatus. This area showed an increase of about 8% during the first half of 1958, as compared with the similar 1957 period. This reflects the rise in spending for research and development, a trend that is expected to continue during the second half of the year.

Component Instruments. Increased expenditures for guided missiles during the past fiscal year have more

TABLE 3. COMBINED VALUE OF SHIPMENTS OF STANDARD INDUSTRIAL CLASSIFICATION INDUSTRY GROUPS 3613 (3611), 36162 (3622), 3811, 3821, AND 3831*, 1947 THROUGH 1958

(Millions of Dollars)

Year	Value of Shipments
1947	916
1948**	1,713
1949	945
1950	1,077
1951	1,562
1952	1,970
1953	2,242
1954	2,304
1955	2,424
1956	2,859
1957**	3,251
1958**	3,251

*S.I.C. numerical designations in parentheses reflect the present designation following the revision of Standard Industrial Classification in 1957. It is noted that 3822 was split off from 3821 as the result of the revision.

**Estimated.

Source: Census of Manufactures for indicated years.

than offset the decline in purchase of military aircraft. This trend is expected for the 1959 fiscal period, with a significant portion being devoted to aircraft and missile ground support equipment, which contains a high instrument content from a cost standpoint.

Overall 1958 Instrument Sales. On an overall basis, the 1958 instrument sales are expected to approximately equal the $3.25 billion estimated for 1957. The downward push to sales of industrial instruments has evidently been arrested, while the plus factors of increased spending by the Department of Defense for end products containing instruments or their mechanisms and the increased emphasis on research and development will undoubtedly help to restore the overall sales to last year's level (See Table 3).

The 1959 Outlook

The most recent survey on anticipated capital investment for 1959, compared with 1958, shows both increases and decreases. On the plus side, increases in outlays are planned by the following industries: petroleum—6%; rubber products—20%; stone, clay, and glass—11%; food and beverages—10%; miscellaneous metals—2%; automotive equipment—4%; non-electrical machinery—1%.

The following declines in capital spending are expected: iron and steel—13%; nonferrous metals—22%; textiles—13%; paper and pulp—6%; electrical machinery—2%; chemical—8%. However, the major portion of the planned 1959 capital expenditures by these industries, which still amounts to about $3 billion, will be devoted to modernization rather than additional plant capacity, thus reflecting a higher ratio of industrial instrument sales per dollar of capital spending.

Expenditures by public utilities are expected to level off at the 1958 annual rate.

After weighing the favorable against unfavorable factors, sales of industrial instruments should manifest a slight increase in 1959.

With the emphasis placed on the investigation of problems related to astronautics, a rise in Federal outlays for research and development facilities is anticipated. Spending by private industry should also continue in the upward direction during 1959. Hence an increase in laboratory instruments and apparatus may be projected for 1959.

Increases are expected in military spending for guided missiles, as well as for ground support stations. Similar increases may be anticipated for the equipment used in connection with air defense warning systems, target detection and tracking apparatus, as well as electronic equipment.

On an overall basis, 1959 sales of instruments are expected to rise from 10 to 15% above the estimated $3.25 billion for 1958.

We Start The New Year Happy

YOUR EDITORS are happy with this issue for several reasons. First, the subject matter is basic and fundamental to modern instrumentation, science, and engineering. Second, each phase of the subject is beautifully covered by some of the country's leading men. Third, we know of no other issue we have brought out in recent years of greater importance—and there have been some really great issues recently!

The philosophy of this issue grew out of your editor's work as Chairman of the Instrumentation Division of the Pittsburgh chapter of the American Institute of Electrical Engineers. Much time was spent in roundtable discussions of "What does the average electrical engineer need to know most in instrumentation?"

As you can imagine, the discussion started with control computers, data handling, load-frequency control, and automatic dispatch, continued through magnetic amplifiers and semiconductor electronics—but ended in agreement on one subject. This was, essentially, that the average electrical engineer's greatest need (and this applies to all others also) is knowledge of the *basic uses and limitations of basic electrical indicators.*

At our invitation, Russ Brownell of Sensitive Research Instrument Company came to Pittsburgh to address the American Institute of Electrical Engineers chapter on the subject of basic movements. Two articles in this issue are a result; Russ covers basic movements in a manner that no engineer or student should miss.

We then obtained beautiful discussions of the potentiometer and electrodynamometer from other authorities. Together, these articles represent THE fundamentals of electrical instrumentation *from the users' standpoint.* Your editors hope that you enjoy reading these articles as much as we enjoyed developing them for you. ¢ MHA

Accuracy Factors of

Knowledge of the various movement constructions and principles is necessary for proper selection and use of basic electrical movements. Grades of accuracy and scale factors also are discussed.

NO AMMETER OR VOLTMETER automatically points to the right value for all given applications. You can rely on any properly designed instrument only if you know what it is supposed to read and how the instrument operates. For example, consider these two commonly "accepted" statements:

1. Ammeters measure current and are connected in series with the load. Therefore, it is proper to use an ammeter with the lowest possible resistance in order to minimize our loss and avoid introducing a load error.

2. Voltmeters measure potential difference and are connected in parallel with the load. Therefore, it is proper to use a voltmeter with the highest possible resistance in order to minimize our loss and avoid introducing load errors.

These two "common sense" statements are NOT always true. A study of the factors governing accuracy in the usual type of electrical indicating instruments shows the reasons why these commonly held beliefs are sometimes wrong.

Sensitivity vs Accuracy in a P-M M-C Movement

The permanent-magnet moving-coil type of instrument (Fig. 1) is commonly called a D'Arsonval movement, although this name should be reserved only for suspended galvanometers. This is the simplest ordinary type of d-c instrument; the magnet is usually of Alnico. A turning force, developed due to current through the moving coil, acts in opposition to a spring and thus moves a pointer across a scale by an amount proportional to (1) the current through the coil, (2) the number of turns in the coil, and (3) the flux density in the gap.

We can do three different things to increase the sensitivity of the instrument:

1. We can install *weaker springs*, but we reach a limit when the spring gets so weak that it tends to sag and fall out of shape.

2. We can increase the *strength of the magnet* and thus the flux density in the gap. Once again we reach a limit, the limit of commercially available magnet materials.

3. We can increase the number of *coil turns*. We can only increase the turns by using finer wire and we quickly reach a limit with the finest wire that is possible to obtain. Note that we are limited in all possible approaches to increasing the sensitivity.

Increasing the magnet strength or the number of turns will not directly affect the instrument's accuracy or ruggedness, but *changing the spring strength will*. The stronger the spring, the better the movement is held in position, and the more repeatable will be the reading. Inaccuracies due to friction and stickiness in the operation of the movement will tend to be swamped out as the spring strength is increased.

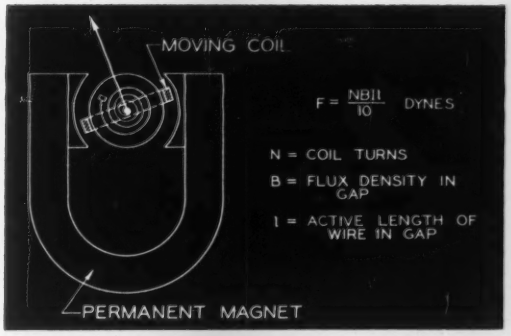
Designing for use with a stronger spring means that we must develop greater amounts of torque in order to swing the pointer to full scale. This means that we must put on more turns and thus increase the resistance of the moving coil. Therefore, we may say that if we want a high-accuracy rugged instrument, we must pay for it by having higher resistance. This statement is, of course, based on the current sensitivity of the d-c instrument.

If in current measurements you specify an extremely low-resistance instrument, remember that you *must pay for it* in more susceptibility to friction and lack of perfect centering of the coil; these factors tend to *reduce the over-all accuracy* and ruggedness of the instrument. In other words, you have a lower accuracy instrument any time you specify the instrument with the lowest resistance. For best instrument accuracy, the specification should always call for the highest resistance the circuit can possibly tolerate for all *current* measurements.

The converse of the above statement is true for voltmeters. The tendency is to specify a high resistance instrument to reduce the load on the circuit; unless

Basic Movements

H. RUSSELL BROWNELL
Sensitive Research Instrument Corp.



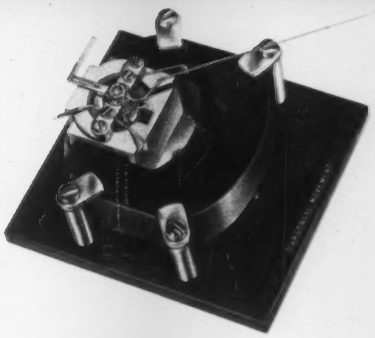
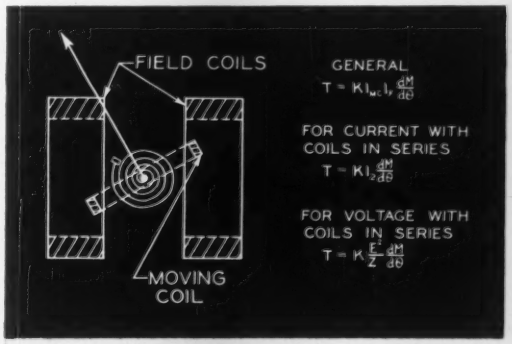


FIG. 1. PERMANENT-MAGNET moving-coil instrument. Top shows force-balance elements; bottom shows typical structure.

FIG. 2. DYNAMOMETER movement is best a-c movement and can be calibrated with dc.



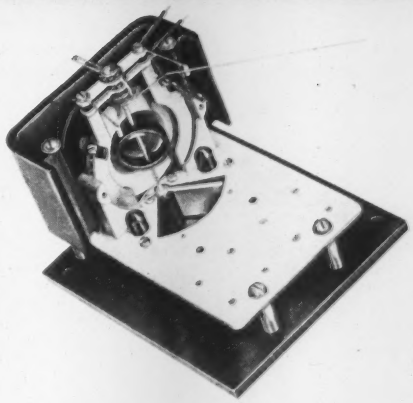


FIG. 3. DYNAMOMETER with one field coil removed to show moving coil and air damping vane.

this is an absolute circuit necessity, *don't do it!* Specify a *low-resistance* voltmeter and allow it to burn up some power. In burning up that power, it will operate with stronger springs and be a better, higher accuracy instrument.

Another popular fallacy occurs when the design engineer says, "I am going to work in the range from 10-100 mils, so I'll buy a 4-range instrument with ranges of 1 mil, 10 mils, 100 mils and 1,000 mils." The *most sensitive* range of an instrument determines how good the instrument is—the more sensitive the basic range, the less accurate and more expensive the instrument will be. In general, therefore, the statement can be made—*do not add range extension in the direction requiring greater sensitivity unless these more sensitive ranges are necessary.*

Position vs Accuracy

When you require high sensitivity and high accuracy, one should always operate the instrument in a horizontal position (with the pivots in a vertical position). A vertical pivot working in a jewel bearing will drop into the middle of the circular jewel and give you a positive point about which the rotation takes place. If, however, you stand the instrument on edge and the pivots are in a horizontal position, they have a tendency to slide down a bit on one jewel and up on the other, and you have an uncertain center of rotation and reduced accuracy. *All instruments operate more accurately when the pivots are in a vertical position.*

Dynamometer Movements

The most common high-accuracy a-c instrument types use the dynamometer movement. The magnet of the permanent-magnet moving-coil type of instrument is replaced by a pair of field coils which provide the magnetic field in which the moving coil rotates (Fig. 2).

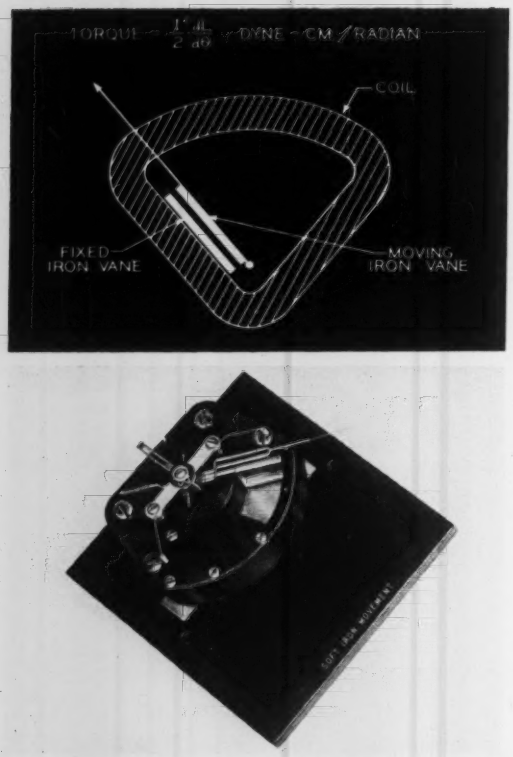


FIG. 4. MOVING-IRON instrument is limited in frequency. Top shows basic elements; typical structure is shown at bottom.

In this instrument the torque is equal to a constant times the current in the moving coil, times the current in the field coil. If we put the two coils in series (as one normally does for use as an ammeter or a voltmeter) the currents in the two coils are equal and the formula reduces to a constant times the current squared (KI^2). Thus the instantaneous torque is proportional to the square of the current through the two coils.

The scale itself contains a square-root factor and, therefore, the reading becomes directly proportional to the root mean square (RMS) value of the current through the two coils. This is important because ordinarily one is interested in the RMS values of the current or voltage involved. Some other types of instruments do not give true RMS values of torque but are calibrated in terms of RMS and hence are accurate only for sinusoidal voltages or currents, as will be seen.

When measuring voltage (by adding a series resistance) the dynamometer movement develops torque proportional to E^2 and, therefore, is again a true RMS indicating instrument for voltage.

The dynamometer is one of the most accurate types of a-c instruments although it does have a relatively heavy and inefficient movement. If we run the maximum current possible through the field coils (limited by a tolerable heating effect), the field produced is still weaker than that of a permanent magnet. This weaker magnetic field means that the torque is considerably lower than would be obtained for similar current in the permanent-magnet moving-coil instrument. Because of this factor, dynamometer instruments cannot be furnished in the high current sensitivities obtainable in the permanent-magnet moving-coil instrument.

The dynamometer instrument, although relatively inefficient and requiring appreciable amounts of power to operate, has an important place in lower frequency a-c measurements which cannot be fulfilled by any other type of instrument because of (1) its inherent true RMS response and (2) its ability to operate for both dc and ac.

Fig. 3 shows a dynamometer movement with one field coil removed so that the moving coil can be seen in position. Below the base plate can be seen the aluminum air damping vane which, moving back and forth in a close fitting chamber, provides the necessary movement damping.

Moving-Iron Movement

A common type of a-c instrument is the moving-iron instrument (Fig. 4). This instrument has two iron vanes—one fixed and one pivoted—both surrounded by the current carrying coil. When current flows in the coil, both vanes become magnetized with identical polarities and thus tend to repel each other. This magnetic repulsion provides a torque which moves the pointer over the scale. The flux in each vane is proportional to the current, and the repulsion force is porportional to the product of the fluxes. Therefore, we again end up with a square factor in our torque formula and have a true RMS-indicating instrument.

The moving-iron instrument tends to be less expensive to construct than the dynamometer. It is somewhat less accurate at higher frequencies because of the magnetic material within the coil and the attendant problems of raised inductance, nonlinearity effects, and similar factors.

Electrostatic Movements

The electrostatic instrument (Fig. 5) is the only instrument made which is truly a "voltmeter." All other types of voltmeters are actually current meters with added series resistance which makes the current become proportional to voltage, and their deflection actually results from the current flow. In the electrostatic movement, the deflection is caused not by current but by the actual voltage applied to the two vanes. As the formula for torque involves E^2, the indications are true RMS values of voltage.

On dc the only current drawn is that of the leakage across the insulation. Thus the leakage d-c resistance is in the order of 1×10^{13} ohms; this results in negligible leakage current for most d-c applications. However, when used on high-frequency ac, the capacitance of the instrument can result in appreciable current being drawn from the circuit, but this current does not contribute to the torque.

A-C Measurement with D-C Movements

Many a-c voltmeters are merely ordinary d-c instruments in series with a resistance and a rectifier. This

may be a tube rectifier, a copper-oxide rectifier, silicon or germanium diodes, or any other type. As shown in Fig. 6, such a voltmeter has a torque proportional to the *average value* of the impressed voltage E. There is no E^2 term, and this instrument will *not* give true RMS value except in special cases.

What is normally done in such an instrument is this: As the average value of E in a rectified sine wave is 0.636 of the peak value, and as the RMS value is 0.707 of peak, the scale is graduated in terms of 1.11 times the average value. If you have a sine wave input, the pointer will point to the RMS values because of the inclusion of this 1.11 factor in the scale. If, however, you use the instrument on anything except a sine wave, the pointer will point to 1.11 times the average value of this wave, which will *not* be the RMS value of this nonsinusoidal wave.

Full-Wave Rectifier

In the full-wave rectifier (Fig. 7) the torque formula is practically the same except for a factor of 2. This method of providing an a-c instrument with a d-c movement is very common and high impedance instruments can be provided with this type of circuit. It is sensitive and accurate on any wave form—if one remembers that its reading is in terms of 1.11 times the average and not in terms of RMS values.

Thermal Convertor

Fig. 8 shows a much abused and sadly misunderstood instrument, and one of the common ways of making an a-c instrument from a d-c movement (a millivoltmeter). We apply the current to the thermocouple through resistance R_2 (we are assuming now that we are going to measure voltage) and R_1 is the heater wire. There is a thermocouple junction attached to R_1 whose voltage output will be proportional to some constant times the temperature of R_1. The temperature of R_1 will be proportional to the wattage dissipated in R_1 which, of course, is I^2R_1; thus we have an I^2 term, and the instrument once again is a true RMS instrument.

Thermocouples have many advantages: (1) They are extremely high frequency devices. Voltmeters and current meters can be made to operate up to several megacycles. In fact, the thermocouple provides the highest frequency measurement which can be made with direct indicating instruments. (2) They have relatively high sensitivities. Voltmeters can be made with a sensitivity of 500 ohms per volt. (3) They have true RMS response. These are the advantages, but: YOU HAVE TO BE CAREFUL IN USING THEM. You can burn out the thermojunction without knowing it, as follows:

The I^2 factor, which causes the true RMS response, causes the operating temperature of the heater to go up as the square of the current through it. Triple the current and the temperature goes up nine times.

Fig. 9 shows what can happen. As the thermocouples of these instruments are made of fine wire, they can reach burnout temperature in a fraction of a second when the current is high. The instrument's pointer, however, cannot move that fast (the instrument is ordi-

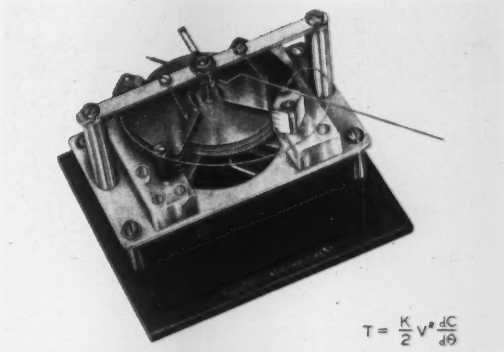


FIG. 5. ELECTROSTATIC VOLTMETER is only true "voltmeter" and has very high d-c resistance.

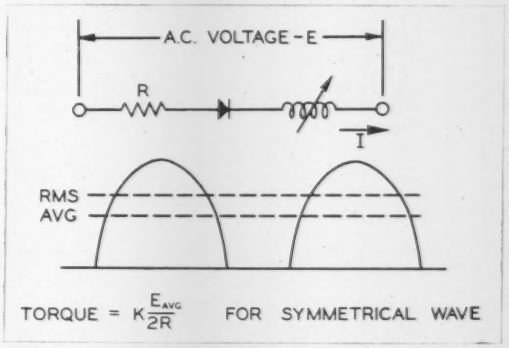


FIG. 6. A-C VOLTMETER using half-wave rectifier and d-c movement. Waveform shows relationship of average to RMS values.

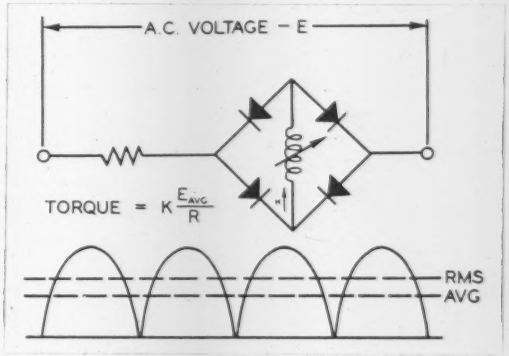


FIG. 7. A-C VOLTMETER using full-wave rectifier plus d-c movement.

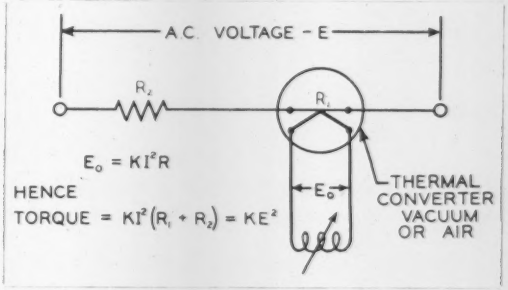


FIG. 8. AC is measured by thermocouple on heater wire. Thermocouple output is shown by d-c millivoltmeter.

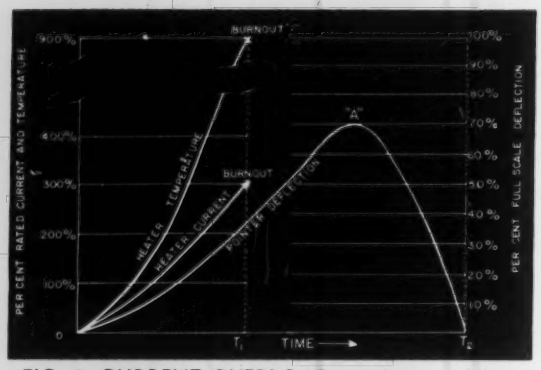


FIG. 9. CURRENT OVERLOAD can burn out thermocouple before pointer approaches full-scale reading.

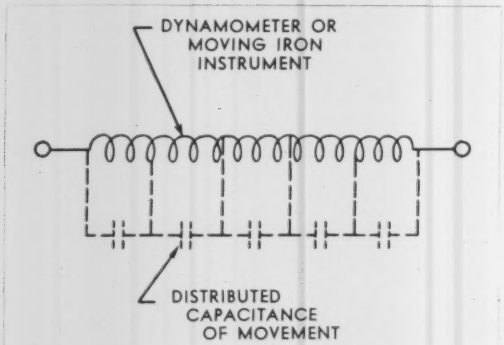


FIG. 10. ANY INDUCTANCE (coil) has distributed capacitance between turns.

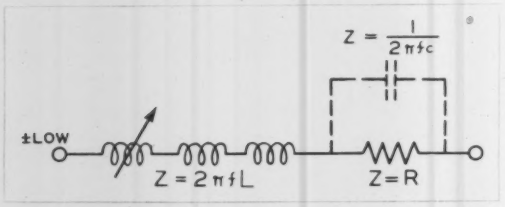


FIG. 11. COMPENSATION of dynamometer movement with capacitor (dotted line) will increase current with frequency to compensate for loss of current through distributed capacitance.

narily heavily damped). As shown in Fig. 9, the current is 300% overload at time T_1 and the thermocouple has actually reached the burnout point, but the sluggish pointer has reached only 40% of scale. As it is moving upward it will coast to a higher point even though the heater is now no longer supplying any temperature to provide thermocouple output. However, before it actually reaches full scale, it will begin to drop back. This factor of the thermocouple burning out much faster than the pointer can respond is the reason for the plaintive comment so often heard: "I didn't burn it out—the pointer didn't go off scale." However, examination of Fig. 9 shows that the thermocouple was overloaded even though the pointer did not go off scale.

Inductive surges are another source of danger. Consider a transformer with dc in the primary, and a thermocouple-type voltmeter across the secondary. If we interrupt the dc in the primary, we get a rapid flux change that can produce a terrific output voltage, limited only by the saturation value of the transformer core. Such a sharp peak can readily burn out the thermocouple.

If we do the same thing with ac in the primary, the switch which breaks the circuit ordinarily will arc slightly and the current will carry over and approach zero gradually, but if we throw the switch often enough, there will come a time when the current will actually break at a peak rather than at zero, and we will get the same terrific transient in the secondary. Once gain the thermocouple, which would take the normal voltage, burned out with the transient peak. The better the quality of the transformer, the more easily it can wreck the thermocouple. The safe way to break the primary circuit is to use a variable transformer in the primary and reduce the current to zero gradually.

Inductive surges are not the only possible cause of trouble. The same thing can happen from a capacitance in the circuit. Any place where there is a possibility of stored energy which can suddenly be discharged into the circuit may be a cause of serious grief to any thermocouples that receive such transient effects. All circuits using thermocouple instruments should be carefully considered with these factors in mind.

Frequency Effects

Dynamometer and moving-iron a-c instruments have relatively high inductance values. Their coils have distributed capacitance (Fig. 10). At higher frequencies an increasing percentage of the current goes through the distributed capacitance and thus does not traverse all the turns of the instrument. Therefore, most dynamometer or moving-iron current instruments tend to read low as the frequency is increased. There are some things you can do about it, within limits.

In a dynamometer voltmeter, the moving coils and the two field coils are connected in series. Also in series is a resistor R (Fig. 11). As the frequency goes up, the inductive impedance goes up, but the impedance of R remains constant. Thus the total impedance which determines the current through the movement will vary with frequency, depending on the ratio of R to L. It is obvious that the frequency characteristics of the instrument will be better if the R to L ratio is high. We can do a certain amount of correction by introducing a capacitance across R so that impedance will tend to go down with frequency. Unfortunately, neither of these effects is linear and you can obtain only approximate compensation this way. Such compensation can be done for instruments operating to as much as 2500 cycles, but seldom higher. When used to the maximum extent, this type of compensation will give an inductive error at low frequency and the instrument will read "low" by the amount of its guaranteed frequency error. At some intermediate point, the capacitive and inductive elements will exactly cancel, and the frequency error will be zero. At the upper limit of frequency, the error will tend to be capacitive and the

A B C D E

FIG. 12. A SHOWS a d-c laboratory standard instrument (volt-amp-milliammeter) with accuracy of 0.05%, realized by use of a built-in standard cell for checking the instrument accuracy. B shows a portable ac-dc volt-milliammeter with accuracy of 0.5% dc and 0.75% ac. C shows a direct-reading frequency instrument with accuracy of 0.25%. D shows a magnetic-core-loss testing set with self-contained ac ammeter, voltmeter, and low-power-factor wattmeter. E shows different types of multirange panel-mount instruments. (Courtesy Sensitive Research Instrument Corp.)

top frequency will read "high" by the full amount of the guaranteed frequency tolerance. Here, you take up the entire guarantee in tolerance in both directions.

Grades of Accuracy

Several general grades of accuracy are involved in electrical instruments. The highest are those with error tolerances of less than 0.01%. These are commonly called "Bureau of Standards type" measurements, although there are several laboratories whose measurements can be considered to be in this class for many ranges of electrical values. These measurements require engineering supervision, and can usually be undertaken only by skilled personnel.

Next in order of accuracy are those measurements made in many laboratories with potentiometers, 4-terminal standard resistors, standard cells, and similar high accuracy devices. These are often referred to as *potentiometric type* measurements. Accuracy is in the range of approximately 0.01% to about 0.05%. These are routine measurements and can be made with reasonable speed. They can be carried on by semi-skilled technical help of less than engineering level with a reasonable amount of training.

Immediately below this level of accuracy comes the best of the direct indicating instruments, usually referred to as *laboratory standard instruments*. These are ammeters, voltmeters, wattmeters, etc., with accuracies of 0.05 to 0.15%. They are long-scale laboratory-type instruments requiring clean, vibration-free, temperature-limited areas, and protection against overload abuse and similar mistreatment to insure long term stability. Readings with this type of instrument are rapid. In recent years a number of routine commercial measurements have required this degree of accuracy, and instruments of this type are now often seen in actual production equipment.

The next class of instruments has no generally accepted name. They are variously known as *portable standards*, *secondary standards*, or sometimes transfer standards* because of their common use for transfer of measurements from the laboratory to production equipment.

*The term "transfer standard" should be reserved for those instruments which are operable at full accuracy on both dc and ac, and are used for the transfer of potentiometric d-c measurements to a-c values.

Accuracies in the order of 0.25% and 0.5% are common in this class; some in the extremely high sensitivity ranges are rated at 1%. When used for the calibration of production equipment, such instruments must have an appreciably higher accuracy than the equipment being calibrated, and should be removed from the actual production instruments for several reasons: (1) The intermediate instruments take a lot of use off the plant standard instrument thus increasing long term stability. (2) It allows the plant standards to remain in the laboratory and prevents "in transit" damage during production checks. (3) It is usually possible to use multirange instruments as the intermediaries between the plant standards and the production equipment by making the laboratory checks at the same scale points that will be used for the production equipment checks.

Reference Accuracy Increments

The general thinking in regard to how much increased accuracy is required in an instrument to use for checking another instrument has changed in recent years. The factor of 10, which many organizations have for many years felt necessary, has been modified. Factors of 2 to 4 are now generally accepted as satisfactory. This means that to check 1% production instruments, 0.25% or even 0.50% instruments are satisfactory in normal operation. In practice, there may be good reason for checking against instruments of the same accuracy class. For example, instruments sometimes are subject to overload in normal operation. One instrument of the same grade, kept aside and used as a reference for those in actual operation, will detect this type of difficulty.

The Meaning of Accuracy

Many people fail to apply correctly the fact that instrument accuracies are normally stated in terms of *percent of full-scale* value. For example, suppose we wish to measure a voltage of 30 volts. We have available a 50-volt ½% instrument and a 150-volt ¼% instrument. If we use the ½% instrument, we have an uncertainty of ½% of 50, or 0.25 volt. If we use the ¼% instrument, we have a measurement uncertainty of ¼% of 150, or 0.38 volt. Hence the more accurate measurement is made with the less accurate 50-volt instrument.

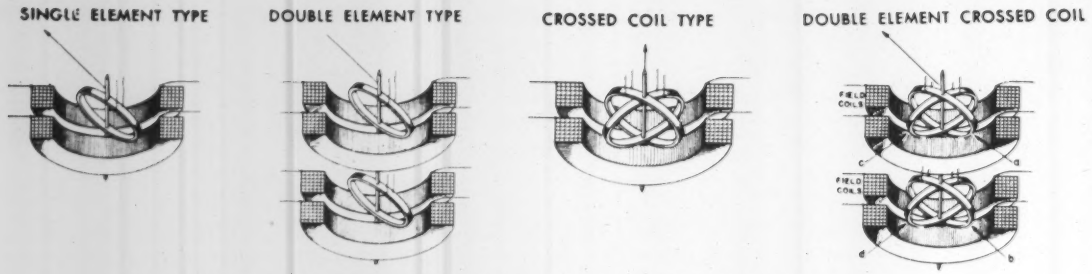


FIG. 1. THE FOUR basic electrodynamometer arrangements.

The Electrodynamometer

The basic laboratory standard instruments for d-c measurements are the potentiometer and precision p-m m-c mechanism; the basic instrument for a-c and d-c/a-c measurements is the electrodynamometer. Here is a survey of electrodynamometer uses.

R. F. ESTOPPEY
Weston Instruments Division
Daystrom Inc.

ELECTRODYNAMOMETER MECHANISMS (Fig. 1) are the most fundamental of all of all electrical indicating devices now used. They are the most commonly used movement for all precision electrical *a-c* measurements. They indicate the rms value of a current or voltage. The mechanism is current sensitive—the pointer moves because of current flowing through turns of wire. It is the most versatile of basic movements—the single-coil movement (Fig. 1) can be used to indicate current, voltage, or power, ac or dc, while crossed-coil movements can be used for power factor, phase angle, frequency and capacity measurements.

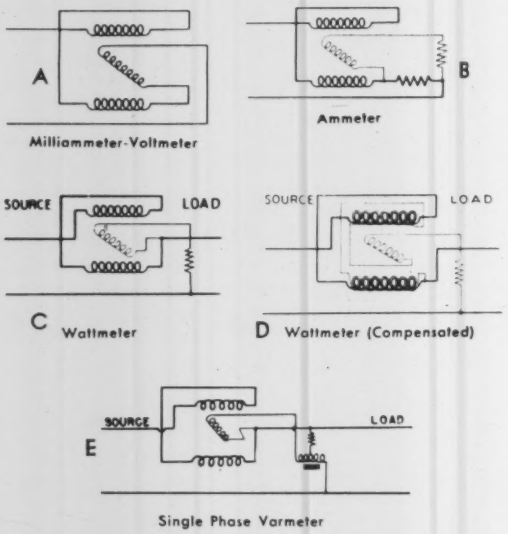


FIG. 2. SINGLE-ELEMENT connections as milliameter or voltmeter, ammeter, wattmeter, compensated wattmeter, and single-phase varmeter.

Perhaps the most important use of this mechanism is as a *transfer instrument* between the basic standards of E, I and R (all of which are defined for direct current only) to alternating current, in which form most of the power of the world is generated, sold and used.

The torque produced in an electrodynamometer moving coil is proportional to the product of the *in-phase components* of the currents in the field and moving coils; the mechanism measures *products*.

Coil Arrangements in Single-Element Type

The single-element type (Fig. 1A) is used as either milliammeter, voltmeter, ammeter, wattmeter, compensated wattmeter, or single-phase varmeter.

Fig. 2A shows hookup for use as a *milliammeter*. The fixed and moving coils are in series. To use as a *voltmeter*, a series resistor is added, as is done to convert any milliammeter into a voltmeter.

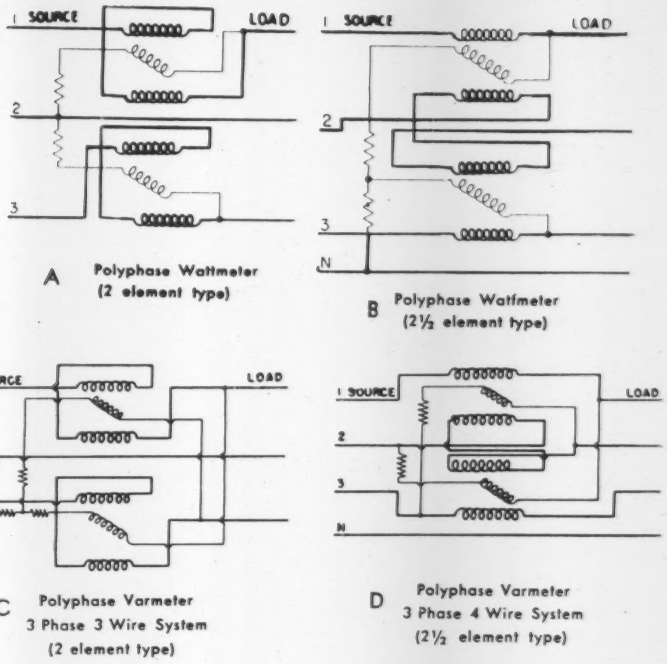


FIG. 3. DOUBLE-ELEMENT unit is used as polyphase-wattmeter or varmeter.

To use the unit as an *ammeter* a series resistor is added (Fig. 2B). This resistor acts as a shunt for the moving coil, so that the current in the moving coil is limited to its safe low value.

To use as a *wattmeter* (Fig. 2C) the field coils carry the full current so that the field is proportional to current, but a resistor is used in series with the moving coil so that its field is proportional to voltage. Hence torque depends on the product of EI cos θ, or active power. Note that when the moving coil is connected across load (as shown), the reading is load power plus the small power of the moving-coil circuit. (If the moving-coil were connected across the source it would read the load power plus the fixed-coil circuit power.)

To cancel the effect of the moving-coil current, the *compensated wattmeter* of Fig. 2D is used. The fixed coils have an extra winding connected in series with the moving coil, which cancels the effect of the moving-coil current. The result is load-power reading alone.

Fig. 2E shows a *single-phase varmeter*. The hookup is the same as for the wattmeter (2C) but the current in the moving coil lags the applied voltage by 90°. Hence only out-of-phase power (volt-amps reactive) is measured. The torque is EI sin θ.

Coil Arrangements in Double-Element Types

The double-element electrodynamometer is used for *polyphase wattmeters* and *varmeters*.

Fig. 3A shows a polyphase wattmeter, 2-element type. Blondel's Theorem states that true power can be measured by one less wattmeter element than the number of wires of the system, provided one wire can be made common to all element potential circuits. In the circuit, line 2 is made common to both potential circuits; the upper field coils are in line 1, the lower in line 3. This connection (common potential-circuit connection) is suitable for single-phase 3-wire, 2-phase 3-wire, and 3-phase 3-wire circuits. A 2-phase 4-wire circuit requires that the potential circuits have separate connections.

A wattmeter for a 3-phase 4-wire system is shown in Fig. 3B. Note that current in line 2 passes through upper and lower field-coil elements, but in reverse direction. The net effect is that the phase is displaced by 60°; this in turn means that the torque effect is one half in each element. Summing of the two elements is effectively the same as having a third element in the third line, provided the voltages are balanced.

Fig. 3C shows a polyphase varmeter for a 3-phase 3-wire circuit. The field-coil connections are the same as the wattmeter of Fig. 3A, but the potential (moving) coils are connected so that the current in each moving coil is shifted 90° from what it was as a wattmeter. The result is vars (reactive power).

Fig. 3D shows a polyphase varmeter for a 3-phase 4-wire system. Note similarity to Fig. 3B, except for potential (moving) coil hookup.

Crossed-Coil Movement

Fig. 1C shows the single-element crossed-coil electrodynamometer. This is used primarily in *power-factor meters*.

Fig. 4A shows a single-phase power-factor meter. Note that it is a combination of wattmeter (Fig. 2C)

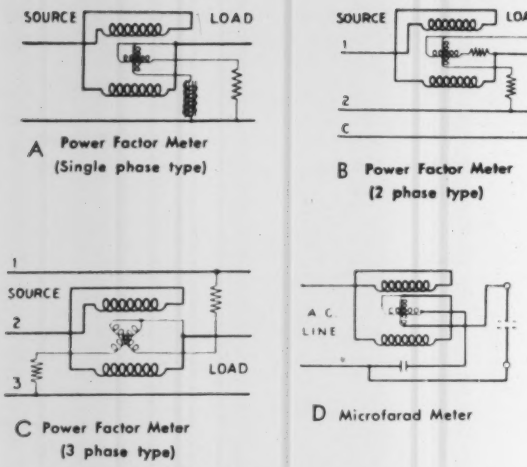


FIG. 4. CROSSED-COIL unit is used as power-factor meter or capacity meter.

and varmeter (Fig. 2E). That is, one moving coil is connected as in a wattmeter, the other has a phase-shifting network as in a varmeter. This is equivalent to mounting a wattmeter and a varmeter on a common shaft so that the torque is a function of the *ratio of vars to watts*. As this ratio varies as the phase angle, the scale is calibrated in terms of the cosine of the phase angle (power factor) of the circuit.

There is no restoring spring in the power factor meter; the final position of the indicator depends only on the ratio of the two torques; the pointer turns until the torque due to active power equals that due to reactive power.

Fig. 4B shows a power-factor meter for a 2-phase circuit. This is the same as the single-phase instrument except for the reactor, which is replaced by a resistor, and connected to phase 2. This provides currents in the moving coil which are displaced by 90° to each other, as is done in the single-phase power-factor meter.

Fig. 4C shows a power-factor meter for a 3-phase circuit. The fixed coils are connected in series in the line used as the common for the moving coils. The latter are connected like wattmeters in opposing legs.

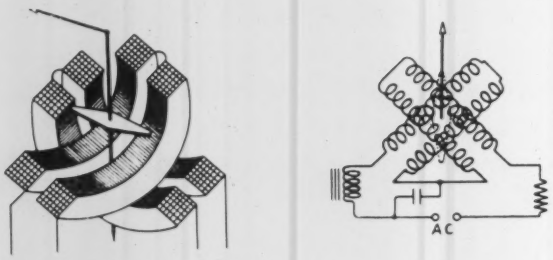


FIG. 6. CROSSED-FIELD unit can measure frequency.

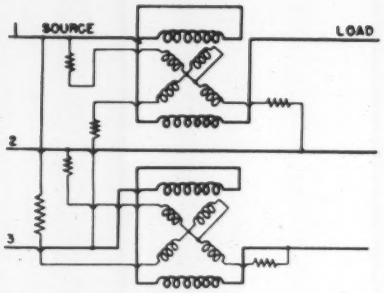


FIG. 5. DOUBLE-ELEMENT crossed-coil unit is used as vector power factor meter for 3-phase 3-wire systems.

The final position depends on the power factor of the circuit—if the loads and voltages are balanced.

Fig. 4D shows a crossed-coil mechanism arranged to measure *capacity*. Ratio of currents through test capacitor (shown dotted) and standard capacitor determine position of movement.

Double-Element Crossed-Coil

This unit (Fig. 1D) is used as a *vector power-factor meter* for 3-phase 3-wire systems, as shown in Fig. 5. Note that this instrument combines the features of a 2-element polyphase wattmeter (Fig. 3A) and a polyphase varmeter (Fig. 3C). Here again the instrument assumes a position proportional to the ratio of vars to watts, or the tangent of the vector power factor angle. It indicates correctly even if the currents in each phase are not balanced (unlike the power-factor meter of Fig. 4C).

Fig. 6 shows a variation of an electrodynamometer for measuring *frequency*. Crossed coils are connected to the line through inductive and capacitive elements. Hence the relative strength of the two fields becomes a function of frequency. A freely rotatable iron vane seeks the direction of the resultant field, which is a function of the frequency of the applied signal.

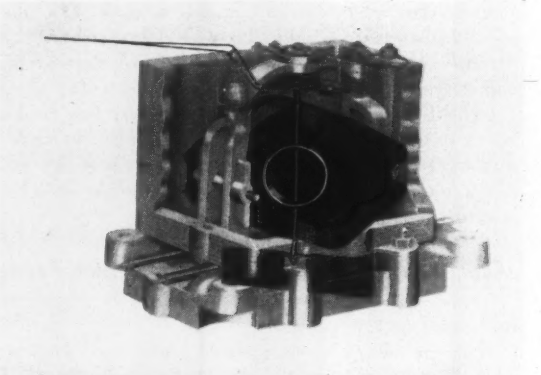


FIG. 7. CUTAWAY view of single-element electrodynamometer.

Use and Maintenance Tips

JOHN E. MILLER
General Electric
Chicago Apparatus
Service Shop

THIS CHECK LIST of guide rules can help you keep your instruments accurate and dependable.

General Rules

1. READ manufacturer's instructions carefully.
2. Handle instruments carefully to avoid injuring instrument bearings.
3. If instrument has more than one range, make connection to highest range first to avoid injury to instrument in event load or voltage has been underestimated.
4. Read instruments in normal operating position—portables horizontal, switchboard types vertical.

Portable Instruments

1. Avoid metal benches; they can affect instrument indication.
2. Use proper size leads; terminals should be clean to avoid contact resistances, especially on millivoltmeters used with shunts.
3. When a shunt is used with a millivoltmeter to read current always check leads to make sure they are the ones with which the instrument was calibrated.
4. If external resistance multipliers are used, check serial number of both instrument and multiplier to make sure of the correct combination.
5. Check instrument zero setting, and if pointer is slightly off, reset to zero by adjusting external zero shifter. Never try to compensate for a bent pointer by moving zero shifter.
6. Do not use instrument in strong fields near cables or bus bars unless it is specially designed for such use.
7. Do not place unshielded instruments close together; one instrument can be affected by magnetic field of other.
8. When an ammeter or shunt is to be used in a grounded circuit, connect it in the grounded line if possible.
9. In connecting a voltmeter to a circuit, connect leads to instrument before connecting to voltage source; this avoids loose leads which may be hot. Be sure voltmeter leads are properly insulated for the voltage to be measured.
10. Arrange instruments, shunts, and leads to avoid danger of knocking them off table or tripping over leads. In measuring high voltages make sure no one will accidentally come in contact with any live parts.
11. When a current transformer is used, *its secondary circuit must be grounded*. Make sure secondary circuit is never opened while current is flowing in primary winding; dangerously high secondary voltage will result. Secondary winding should be short-circuited when changing instruments or when not in use. Cut off line voltage before making primary connections.
12. When a potential transformer is used, *its secondary circuit must be grounded*. Make sure instrument is connected to secondary or low-voltage winding. Cut off line voltage before making primary connections.

Operating Tips

1. Try to have instrument reading between $\frac{1}{2}$ and $\frac{3}{4}$ full-scale value.
2. Never touch bare terminals or binding posts while instrument is energized.
3. Read from directly above the scale so that the pointer and its image in the mirror coincide.
4. If a split-core current transformer is used with an ammeter, make sure transformer-core joints are free of dirt which might cause an error in reading.
5. To avoid temperature errors, do not use conventional instruments at extreme temperatures; use temperature-compensated instruments instead.
6. Use special instruments to measure motor-starting or welding currents.
7. Use a damp cloth to clean an instrument's glass. A dry cloth may induce a static charge and affect instrument reading. (Breathing on the glass will discharge the static.)
8. Do not slam the instrument cover. Be sure binding-post nuts are tight, even when instrument is not in use.
9. If an instrument is overloaded, dropped, or its accuracy doubted, check it against another on several points before using it again.
10. To overcome slight stickiness, tap instrument with fingers. If pointer movement is erratic and tapping appreciably moves the pointer, the instrument bearings may need attention, and should be checked by a competent instrument-repair facility.
11. Connect wattmeters so that both current and potential coils are at the same potential. This is especially important where multipliers are to be used because it can bring on a potential difference between current and potential coils high enough to cause a breakdown.
12. Consider polarity when connecting wattmeters into a circuit.
13. When rectifier instruments are used to measure a-c values, the waveform should be known.

Transportation and Storage

1. Store instruments in a place free from dust, corrosive fumes, and excessive humidity.
2. Slide—do not drop—an instrument into its carrying case.
3. Transport an instrument face down, or up on one end, to reduce weight on the lower pivot.
4. In non-hand transportation, carry an instrument in a padded container to absorb shocks.
5. Do not carry more than one instrument in one hand. If means have been provided for locking the moving element, do it before the instrument is transported.

Repairs

1. Have a competent instrument mechanic, the manufacturer, or your nearest service shop make repairs.
2. When an instrument element is removed from the case for inspection, take extreme care not to get dirt and dust into the instrument.
3. Instrument bearings should never be oiled.

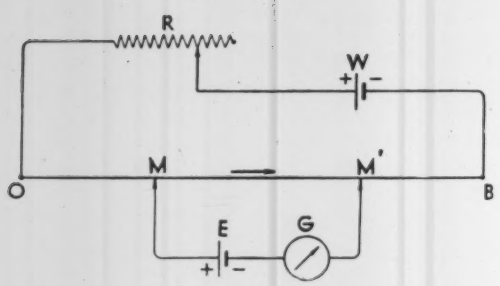


Fig. 1. POTENTIOMETER PRINCIPLE is emf comparison. E is standard cell or unknown emf. A working current is first carefully established by comparison against a standard cell (E). Unknown emf is then substituted for E and measured in terms of IR drop along OB.

PRECISION POTENTIOMETERS

THE POTENTIOMETER has three basic advantages—(1) high initial accuracy, (2) permanancy of calibration, and (3) zero current drain (null-balance) from source when in balance. Thus the voltage measured is the true emf of the source, unaltered by circuit resistance, voltage drops in leads, and detector characteristics. The accuracy depends primarily on the accuracy and stability of the potentiometer resistors and the standard cell.

The potentiometer is not only the basic technique for electrical instrument standardization but also a basic technique for industrial emf measurements—for temperature measurements by thermocouples, for example, or pH measurement by pH cells. Indeed, more potentiometers* are used today for these latter uses than for their original standardization function. The principles for both uses are, of course, the same.

*See Recording Potentiometer Survey, *I&A*, Aug., 1958 and May, 1958.

Basic Potentiometer Principle

The potentiometer measures an unknown potential by comparing it against a known potential. Fig. 1 illustrates this principle.

The heart of the instrument is a calibrated resistance —that is, a conductor of uniform or known resistance per unit length. It is represented by line OB in Fig. 1. G is a galvanometer used only as a null detector; W is a battery used only to produce a *working current* I in OB (adjusted by resistor R).

In using the potentiometer, the working current is first adjusted by comparing the standard cell voltage against an IR drop in OB. This is *standardization*. R is adjusted so that no current flows in the galvanometer. The potential drop across M-M′ will then be equal to E.

For example, let us say that E is 1.0183 volts, and that contacts M and M′ are set so that they span 1018.3 divisions of the calibrated OB scale. If R is adjusted so that no current flows in the galvanometer, the potential drop between M and M′ due to W must

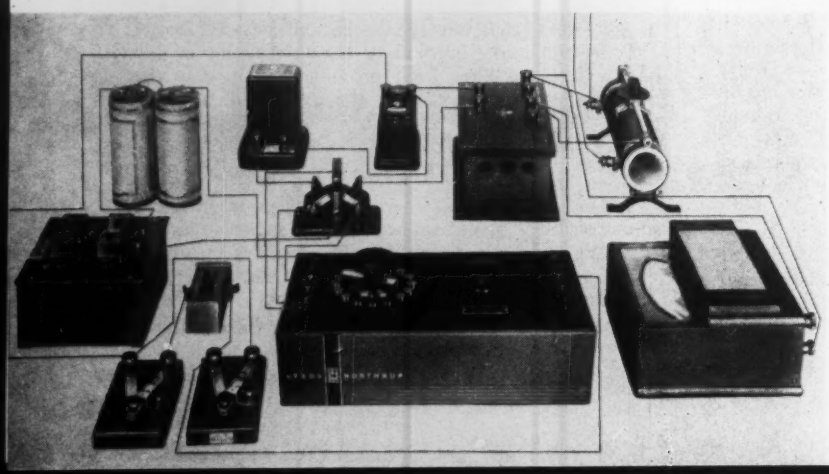


FIG. 3. VOLTMETER CALIBRATION setup shows all the elements of Fig. 2. Voltmeter being calibrated is at lower right. Rheostat at top right adjusts voltmeter indication from outside high-voltage supply. Volt box next to this rheostat drops this voltage to the small emf required for the potentiometer.

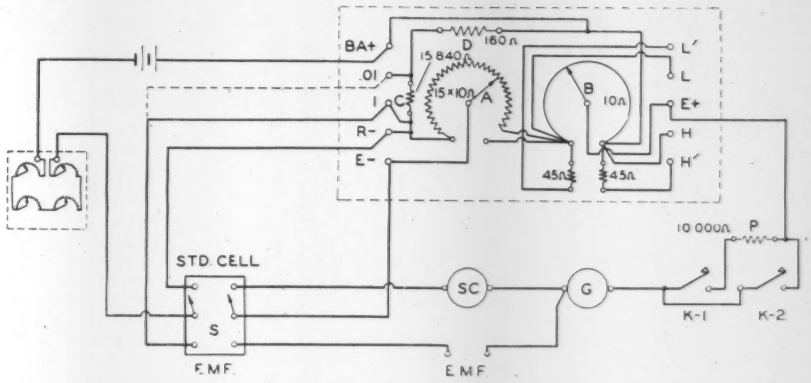


FIG. 2. VOLTMETER CALIBRATION equipment by potentiometer includes potentiometer (in dotted box), battery for producing the working current (top left), standard cell, galvanometer, rheostat box, and various switches.

M. H. ARONSON

The potentiometer is the most precise emf-measuring device available for d-c measurements (except for special Bureau of Standards techniques). Hence it is the basic calibration and standardization instrument for the standardizing laboratory desiring an accuracy of ±0.01% or better. All technical workers should be intimately familiar with potentiometer principles and techniques.

be exactly equal to E. The potential drop through each scale division on OB must now be 0.001 volt.

To measure an unknown potential, E is removed from the circuit and the unknown emf substituted for E. The contacts M and M′ are readjusted so that no galvanometer current flows; the unknown is now read directly in terms of scale divisions, 0.001 v/div.

Students' Calibration Setup

An actual setup for electrical instrument calibration by students is shown in Fig. 2. This student's setup illustrates the principles and accessories.

Switch S selects either the standard cell (SC) or the unknown emf. Switches K-1 and K-2 are key-type switches that permit resistor P to be placed in series with the galvanometer to protect it while making coarse adjustments. When both switches are closed, P is bypassed.

The *resistance box* shown at the left adjusts the working current (about 10 ma; dry cells can be used at top left) so that G shows a null when contacts A and B are set to the certified standard-cell voltage.

C and D are shunt resistors that can change the range of the potentiometer. When connection is made to post 1, the current through A and B is 100 times that through C and D; however, when connection is made to post 0.01, the current through A and B is one hundredth that through D. The total current remains the same. Thus the two ranges of the instrument are say, 0 to 1.6 volts and 0 to 0.016 volt, selected by connecting to the proper binding post. The high range is usually used for instrument standardization; the lower for low-emf measurements.

Note that in the low (0.016-v) range reduced current flows through the calibrated resistor—hence each division represents a smaller emf than in the upper (1.6-v) range.

Note that the standard cell and the unknown are always connected into the circuit via the sliding contacts A and B; it is the potential drop between A and B that actually measures the emf.

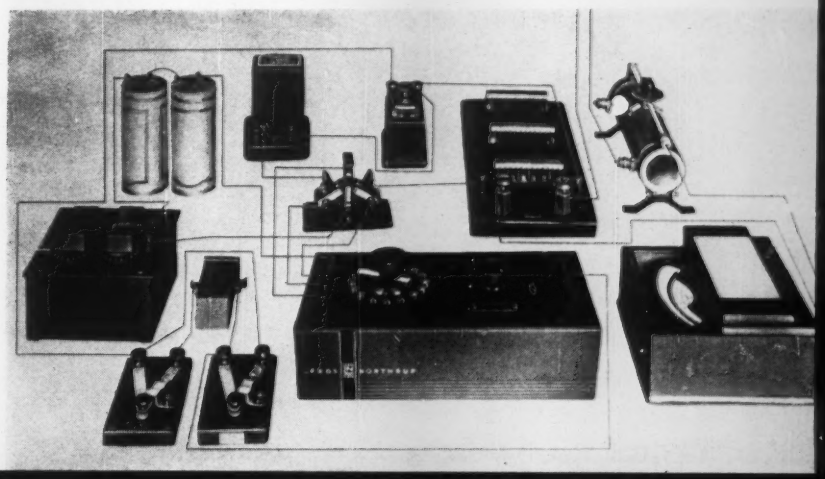


FIG. 4. AMMETER CALIBRATION setup uses emf drop across standard resistor as input to potentiometer. Here the resistor is 0.1 ohm, 15-amp capacity (L&N 4360).

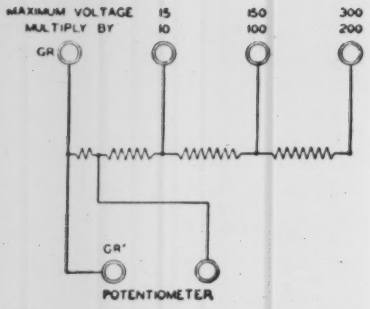


FIG. 5. VOLT BOX extends range of potentiometer for voltage measurement.

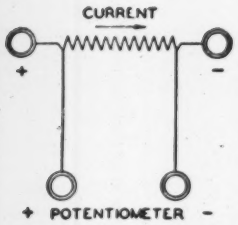


FIG. 6. STANDARD RESISTOR is used for measuring current. Note that resistor has four terminals—two current and two potential.

FIG. 7. SHUNT BOX. (Courtesy Leeds & Northrup)

The standard cell must always be connected to the upper (1.6-volt) range. In the circuit of Fig. 2, both the unknown and SC are connected to the upper range. When using the lower range for the unknown, the dotted-line connection should be made. This permits the SC to be connected to the upper range and the unknown to the lower range, automatically.

For measurements above 1.6 volts, it is customary to use a voltage divider known as a *volt-box* (Fig. 3). Volt-box resistances are usually high (200 ohms per volt) so that only small current is drawn from the source.

For *current measurement*, as in calibrating ammeters and wattmeters, the current to be measured is passed through a *standard resistor* (Fig. 4), and the potential drop across the resistor is measured by potentiometer. A *shunt box* (Fig. 7) can be used to extend the potentiometer range for current measurement.

Fig. 3 shows an actual student setup corresponding to the circuit of Fig. 2. A voltmeter at lower right is being calibrated.

Fig. 4 shows a student setup for calibrating an ammeter. The ammeter is shown at lower right. Here again a potential drop (across the standard resistor) is measured by potentiometer.

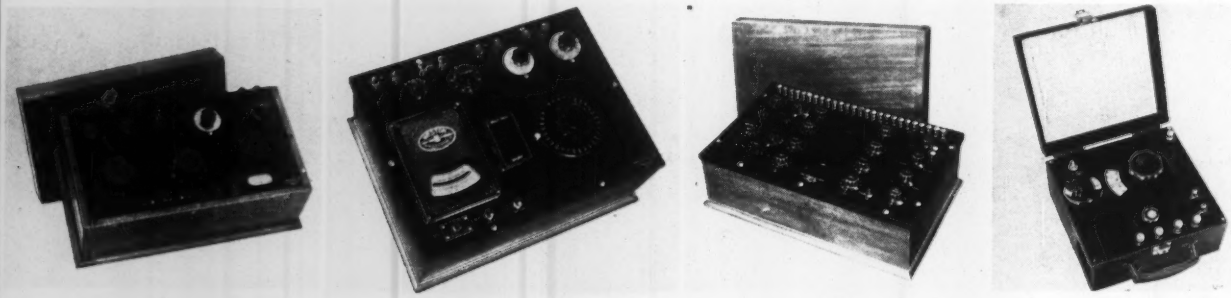
Features of Available Potentiometers

A student setup has been used to demonstrate the principles and accessories used for potentiometric measurement. In industrial and research practice, manually balanced potentiometers are used that range in accuracy from small portable instruments to the Wenner Standardizing Potentiometer, perhaps the most accurate type available.

Fig. 8 shows a typical line of potentiometers. A shows a laboratory standard with accuracy of 0.01%; B shows a deflection potentiometer which combines the accuracy of the potentiometer with the rapidity of deflection-type reading; C shows a White Double potentiometer which combines two potentiometers in one. This unit permits two sets of readings in rapid succession (as from two platinum couples in calorimetry) on the same potentiometer resistors, but without changing the position of the first set of dials in order to read the second. D shows a portable potentiometer for plant use.

Another large line of potentiometers is offered by Leeds & Northrup, including several portable potentiometer models, the Brooks Deflection potentiometer, Wenner potentiometers, and the popular K3.

The Wenner potentiometer deserves special mention.



A B C D

FIG. 8. TYPICAL LINE of potentiometers. (Courtesy Gray Instrument Co.)

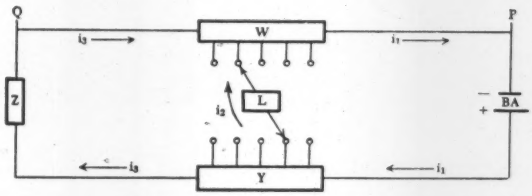


FIG. 9. PRINCIPLE of Wenner decade. (Courtesy Leeds & Northrup)

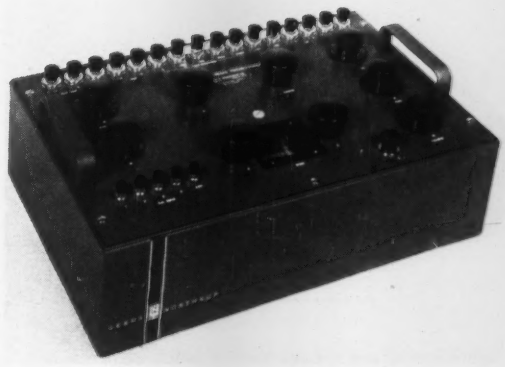


FIG. 10. L&N K3 potentiometer.

It uses a circuit developed by Dr. Frank Wenner of the NBS, which minimizes parasistic emf's and resistance variations at the potentiometer contacts. The principle is shown in Fig. 9. W and Y are equal-value decades so that the battery load (and hence currents i_1, i_2, and i_3) remain constant. However, the output voltage PQ (for the potentiometer) can be adjusted between the maximum value of $W(i_2 + i_3)$ and the minimum value of Wi_3. The constant current, and the circuit arrangements in which thermal emf's tend to oppose each other, means that resistance changes at contacts and parasitic emf's are minimized.

The K3 potentiometer (Fig. 10) is a potentiometer decade plus two Wenner elements. It features ranges of 0-1.6110 v, 0-0.16110 v, and 0-0.016110 v. Accuracy is 0.01% plus 20 μv on high range; 0.015% plus 0.5 μv on the low range. The supply battery drain is 24.4444 . . ma. This instrument has several advanced features in zeroing and guarding, and also features an auxiliary potentiometer for making measurements that require one emf to be held and checked while another is measured (as in calorimetry, temperature measurement with 4-terminal resistance thermometers, wattmeter checking, etc.).

Fig. 11 shows the Rubicon Type B, one of the line offered by Rubicon Instruments Div., Minneapolis-Honeywell. This instrument also has three-ranges—1.6, 0.16, and 0.016 v, and the auxiliary current source required is 11 ma.

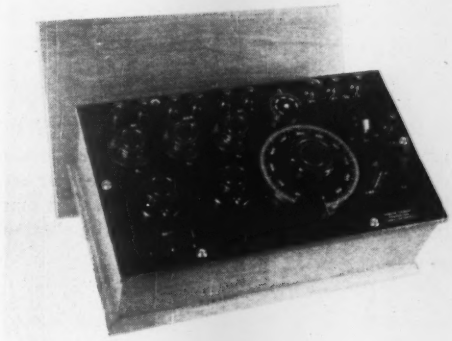


FIG. 11. RUBICON Type B.

The instrument shown in Fig. 12 is a portable potentiometer with interchangeable direct reading scales for temperature measurement with three different types of thermocouples. It also "is only portable potentiometer with interchangeable scales *and* automatic compensation." The power supply is a mercury battery. Weight is only 14 lbs., dimensions 12¼" x 9" x 8½".

FIG. 12. SMALL POTENTIOMETER for temperature measurement. (Courtesy Technique Associates)

Potentiometer Accessories

The basic accessories include standard cell, galvanometer, volt box (for voltage measurements above 1.6 v), calibrated and standard resistors and shunt box (for current measurement). A future issue of *I&A* will discuss these accessories in detail.

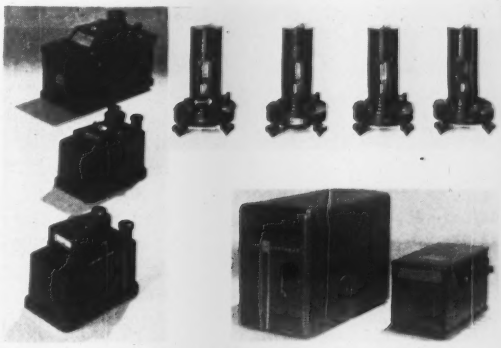


FIG. 13. GALVANOMETERS include pointer types (A), reflecting types (B), and enclosed lamp types (C). (Courtesy Leeds & Northrup)

Acknowledgement

The assistance of G. R. Goettelman, Leeds & Northrup Company, is gratefully acknowledged.

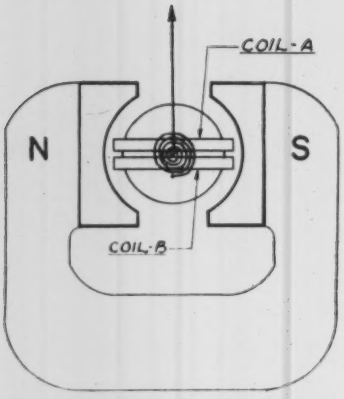


FIG. 1. PERMANENT-MAGNET moving-coil instrument with two coils will add or subtract. Use as comparator results in high accuracy.

LESSER KNOWN USES OF BASIC

It is not widely known that basic electrical movements can perform many computing functions, often with startling accuracies in comparative measurements.

BASIC ELECTRICAL INDICATING INSTRUMENTS can be used for addition, subtraction, comparisons, multiplying, intergrating, and other computing functions, with no electronic circuitry. In many cases startling comparative accuracies can be obtained.

Differential Movement

If we take an ordinary permanent-magnet moving-coil instrument and, instead of winding a single coil, wind two coils (Fig. 1), we produce what is commonly called a *differential instrument.* If we put a current through coil A, the instrument deflection is proportional to that current. If we put a current through coil B, the instrument deflection is proportional to this current. If both coils are identical and if we put currents through both coils in the same direction, we have an instrument that indicates A plus B. It will *add* any two current values and the pointer indication will be proportional to the sum of the two currents.

This same instrument can be used for subtraction simply by reversing the current through one coil.

Let us assume that we make a 50-0-50 microammeter of this differential type. A current of 1 microamp in A and 0 current in B now gives you 1-division deflection due to the current in A. If, however, we put 100 microamps in A and 99 microamps in coil B, the pointer still indicates only 1 microamp (current A minus current B).

The advantage of this differential instrument comes from the fact that the above described 50-0-50 microammeter can handle momentary currents in the order of 10 milliamperes without damage to the instrument. Therefore, if we apply 10 ma to coil A and 10.001 ma to coil B, we obtain a 1-division deflection in the direction of the coil B. Note the accuracy. If we assume that our original 50-0-50 microamp instrument had an accuracy of ± 1% (± 1 division), it has ± 1 microamp accuracy with 10 ma flowing. In terms of the accuracy of comparison, we are now able to *compare* the 10 ma to an accuracy of 0.01% (1 division deflection). We do not know that one is 10 ma and the other 10.001, but we do know that their difference is .001 ma, and that the two currents are within 0.01% of each other.

This high comparative accuracy results from the overload characteristics of the permanent-magnet moving-coil instrument. Most of these instruments can be overloaded 100 to 1 temporarily, in some cases even 200 to 1. The basic accuracy of the instrument is effectively multiplied by the overload factor.

Current Comparator

In Fig. 2 we have a differential instrument in a circuit with a standard resistor, a high sensitivity galvanometer, and a standard cell. By means of the standard cell and galvanometer, we can know the current in one coil of our instrument to an accuracy in the order of 0.01%. With sufficiently stable power supplies, checking of this current once an hour can hold this degree of accuracy.

Now, by means of the differential instrument, we can compare other currents to this standardized value to a high degree of accuracy because of the overload characteristics of the differential instrument. We have turned our high comparison-accuracy into a high *absolute accuracy* by the addition of this standard cell circuit. Recent advances in high-accuracy high-stability power supplies are leading to the use of a type of circuitry using the high comparative accuracy of the differential and the high reference accuracy of special supplies to provide long-scale, high-readability, high-accuracy standard instruments.

Crossed-Coil Ratio Comparator

Fig. 3 shows a different type of comparison instrument. Instead of the usual angular gap, we have provided a magnetic structure giving a straight-line flux pattern. In this instrument coil 1, when it is supplied with current, tends to swing the pointer to the right as it moves to enclose a greater number of flux lines. Similarly coil B tends to swing the pointer to the left.

ELECTRICAL INSTRUMENTS

H. RUSSELL BROWNELL
VINCENT P. CRONIN
MARVIN I. STEINBERG
Sensitive Research Instrument Corp.

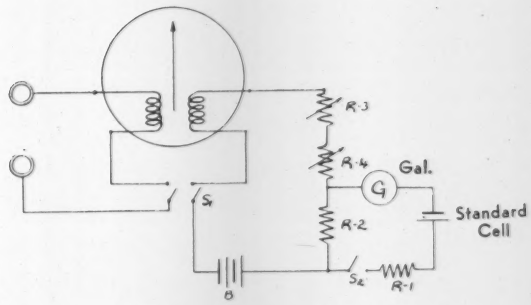


FIG. 2. CURRENT COMPARATOR compares unknown current in left coil with "standardized" current in right coil.

In this instrument currents are brought into the coils A and B by light, gold ligaments which introduce negligible restoring torque. There are no springs for restoring torque.

As the coils swing, they change the number of flux lines they enclose and thus change the torque which they provide. When currents are put through both coils simultaneously, the pointer takes up a position so that the coils produce equal and opposite torques. The one carrying the most current will, of course, be in a position to intercept the greatest number of flux lines. If all the current is in coil 1, the pointer swings to the right index. If all the current is in coil B, the pointer swings to the left index. If the two currents are exactly equal, the pointer remains vertical. For any currents, the pointer takes up a position which can be marked on the scale in terms of the ratio A/B. We now have a comparison device which gives literally infinite range, having zero at the left index and infinity at the right index, and covering the entire range between.

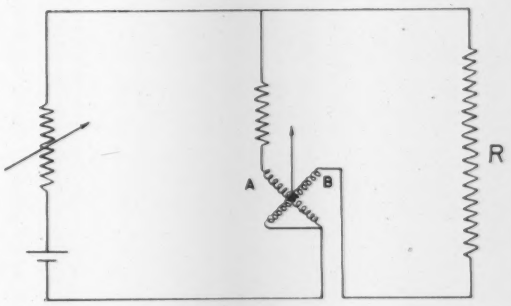


FIG. 3. MOVEMENT FOR obtaining the ratio of two currents.

A specific use for this type of instrument is measurement of resistance while current is flowing (Fig. 4). Coil B is connected in series with resistance (R) to be measured. Coil A is connected to a series resistor to make its current proportional to voltage. If we now cause a current to flow through resistor R, the ratiometer pointer will assume a position which will indicate the ratio A/B, which in this case is the ratio E/I, E being the voltage across the resistor, and I being the current through it. This ratio (E/I) is R. Therefore, we can calibrate the scale of the ratiometer in terms of the resistance R, and it correctly indicates the value of R *regardless of the current or voltages applied.*

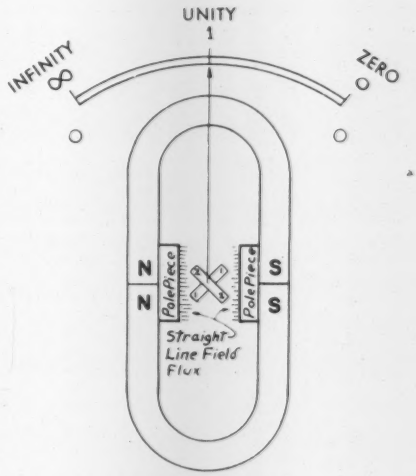


FIG. 4. THIS RATIO instrument can give resistance directly.

Let us describe one use for this technique which has proved of value in surgery. There is a tropical venereal disease in which the aorta tends to lose its strength and begins to swell out like a blow-out in a tire. Eventually it bursts and the victim dies.

Presbyterian Hospital in New York has developed a surgical technique where they feed a nickle wire inside of the aorta, like the reinforcing wire in a vacuum

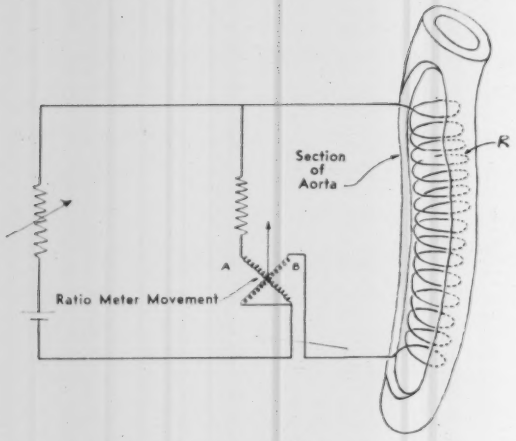


FIG. 5. RATIO TECHNIQUE used in surgery.

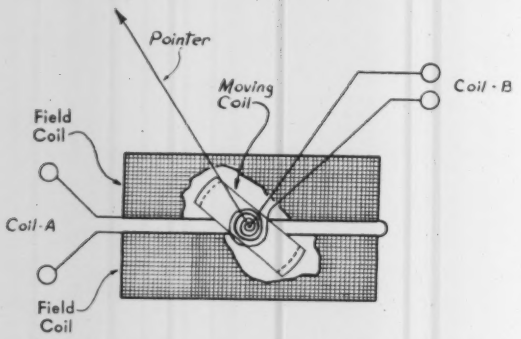


FIG. 6. DYNAMOMETER movement is multiplying element.

cleaner hose (Fig. 5). They run a current through this wire. If the wire reaches exactly the right temperature, it will sear the aorta walls and adhere to it, remaining to provide reinforcing for the aorta. It was so difficult to control the current properly that the operation was successful in about one out of four times. If the wire got too hot, it burned a hole in the aorta and the patient died then instead of a few weeks later. If it didn't get hot enough, it didn't sear to the aorta and the aorta eventually burst anyway. The trick was to get the wire to exactly the right temperature.

First they tried to measure the resistance by bridge methods because, with the high temperature coefficient of the nickle wire, this was a measure of the temperature of the wire. This necessitated throwing off the heating current during the actual period of measurement. The blood flow cooled the wires so fast that resistance measurements of this type proved to be of little value. Actual measurements of the current involved proved to be of little value because the blood flow was different for different patients, and the same current did not provide the same temperature in every case.

The problem was solved by setting up a ratiometer in the circuit shown in Fig. 5. This is the same as Fig. 4, resistance R being the actual wire in the man's aorta. The ratiometer now reads the actual resistance of the wire regardless of the current flowing at the moment. The operation was then performed several times and the ratiometer readings were recorded until a pattern of correct values could be obtained. As soon as this was determined, a red line was drawn on the scale, and it is now merely necessary to turn on the current, bring it up until the ratiometer indicates the correct resistance (which is also the correct temperature), hold it for an exact number of seconds, and turn it off. The ratio of successful operations has gone up from approximately one out of four to approximately eight out of ten.

Multiplying Dynamometers

The deflection of a dynamometer (Fig. 6) is proportional to the product of the current in the two coils. Thus if these are two separate currents, we have an instrument which automatically multiplies, and which operates on dc or ac.

If this instrument is used on ac, the phase angle between the two currents must be applied because the deflection is proportional to the current in coil A times the current in coil B, times cosΘ. This same formula (AB cosΘ) also defines torque in many mechanisms and a-c devices. For instance, in conventional servomotors, the torque is proportional to the current through one phase times the current in the other phase times the cosine of the angle between the two phases. If in making measurements on such a device we put one coil in phase A and the other coil in phase B, we can use a single meter to read torque instead of having to take two separate readings and the measure of phase angles.

Fluxmeter

The fluxmeter (Fig. 7) is the same basic permanent-magnet moving-coil instrument except that it is built without springs. The current is brought in and out of the moving coil by fine, gold ligaments that introduce negligible torque, and the pointer will stay at any position on the scale.

The simplest way to think of the action of this instrument is on the basis of conservation of energy. The moving coil is connected to an external search coil. As we have no way of getting energy into this circuit, the total flux linkages of the moving coil and the external search coil must remain constant. If we assume that the search coil is originally in a field of high flux density and the pointer is at zero, when the search coil is moved to a point of zero flux the moving coil must move so as to increase its own flux linkages to maintain the total constant. This movement, therefore, is a measure of external *changes in flux*.

The instrument measures the difference between the flux linkages where it was and the position to which it was taken. If you want to actually measure flux lines, you must either start or end at a point of zero flux.

If we substitute a resistor in place of the search coil (Fig. 8) and run a current through this resistor, the fluxmeter pointer tends to move continuously until it hits the pin at the end of the scale. The actual current flow is now indicated by the *rate* at which the pointer moves, and the actual distance traveled becomes proportional to the *integral* of that current with time. We have now made an integrating device that reads, not

in terms of milliamperes, but in terms of milliampere-seconds.

There are two limitations which must be applied for accurate integration with the fluxmeter. The integration time cannot be longer than 15 or 20 seconds because the ligaments used do actually provide a slight torque and the instrument tends to drift. If the period of integration is long, this drift becomes appreciable. Also, the time cannot be so short that the signal is bypassed through the distributed capacitance of the moving coil. Hence integration is satisfactory for any phenomena which is complete in more than 10 or 15 microseconds and not longer than 10 or 15 seconds.

One widespread use of this type of measurement is in photographic work involving various types of shutters. A single reading of the fluxmeter, when supplied from a photocell circuit, provides a measure of total light flux passed regardless of the rate of opening or closing.

Frequency Meters

Frequency meters are included in this listing of computing instruments because in effect they count. One versatile type of frequency meter is shown in Fig. 9. Transformer TR is made with a square-loop-type of material. Resistor R is selected to provide sufficient current at operating voltage to drive the core material completely into saturation each half cycle. As the core goes completely into saturation, a constant volt-second integral output is achieved for each half cycle. If this is then rectified and sent through a d-c instrument which will integrate the pulses because of its long-term averaging characteristics, the meter deflection will be directly proportional to the number of times the core has been driven into saturation and thus can be calibrated directly in terms of the driving frequency.

When it is not desired to read from zero to a specific full-scale value, suppression can be accomplished and the scale read for a limited frequency range. This is commonly done by using two separate rectifiers and utilizing opposite halves of the wave. One half, fed into the metering circuit is proportional to frequency. The other half-cycle, picked off by a reverse rectifier, is fed into a voltage regulating circuit and a voltage is derived which is stable and *not* proportional to frequency. This voltage is used for a bias to provide offset operation. By this means, it is possible to obtain a 375-425 cycle instrument for the measurement of a 400-cycle apparatus. This basic type of frequency meter is a relatively sensitive device and performs satisfactorily up to several thousand cycles. The current drain can be as little as 5 ma on 115-volt circuits, compared with 40 or 50 ma with some other types of frequency meters. Normal accuracy is in the order of 0.25% of full scale.

In Fig. 10 is shown another common type of frequency meter in which coils A and B are fed from frequency-sensitive networks containing R and L. As frequency is increased, the current through A tends to decrease while the current through B tends to increase. The soft iron needle mounted within the coils tends to take up a position which is the resultant of the two currents and hence gives a pointer indication proportional to frequency.

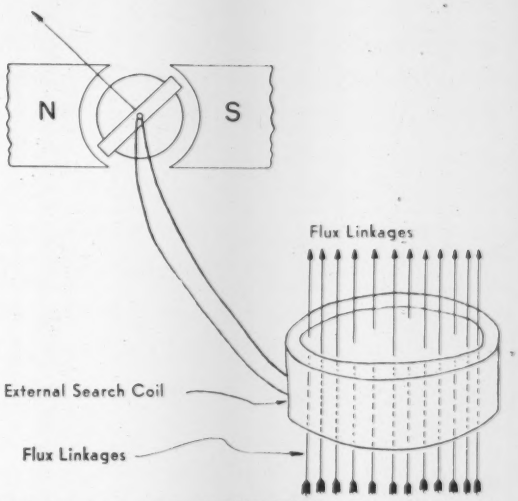


FIG. 7. P-M M-C MOVEMENT without spring is fluxmeter.

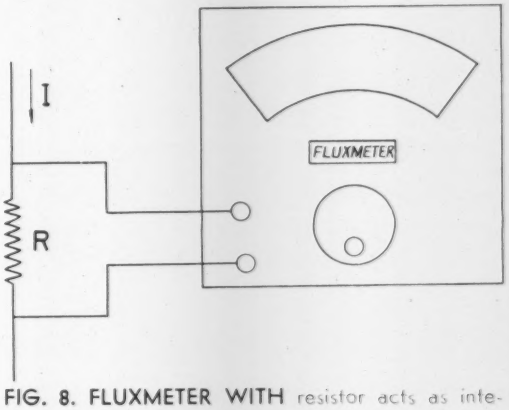


FIG. 8. FLUXMETER WITH resistor acts as integrator.

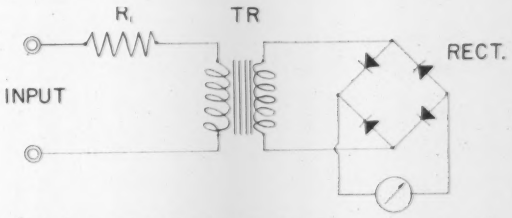


FIG. 9. FREQUENCY METER comprises saturable reactor, bridge-rectifier, and d-c instrument.

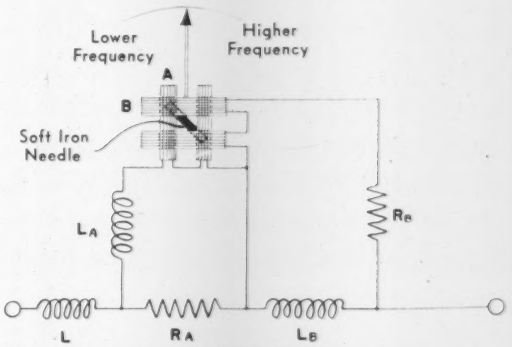


FIG. 10. DYNAMOMETER-TYPE frequency meter.

Local Standards Laboratories

ARCHIBALD T. MCPHERSON, National Bureau of Standards

WHEN the National Bureau of Standards was established at the beginning of the century, nearly all of the needs for standards were met by sending instruments and other standards to the one central laboratory in Washington for calibration. The Bureau is now concerned only with *master* or *reference* standards; users make all the other measurements that are required. Decentralizing standardizing operations is facilitated by *local standards laboratories.*

A system of classifying standards has been proposed by McNish of the Bureau staff. It divides standards into classes, the first class is that of *prototype standards* (Fig. 1). In each class the standards are arranged in order, each of which represents a stage of comparison beginning with the *national (prototype) standard.* The successive orders include (1) *reference* and *working* standards at the national level and (2) reference, working, and shop standards at the local level. An *interlaboratory standard* may serve to connect the national laboratory and the local laboratory.

National Prototype Standards

The prototype standards are so designated because they are the standards in terms of which all measurements in our present system are based and are arbitrarily defined as follows:

DISTANCE: Prototype Meter No. 27

WEIGHT: Prototype Kilogram No. 20

TIME: Approximately 1/86,400th of the time for a mean rotation of the earth on its axis with respect to the sun (or more exactly 1/31,556,925.9747th of the tropical year 1900)

TEMPERATURE: 1/273.16th of the temperature interval between the triple point of water and the absolute zero of the thermodynamic scale.

Time and Frequency

The ideal situation is to make the national standard directly available to the user. This ideal has been attained in the case of one important standard—the standard of time and frequency. Through station WWV near Washington and station WWVH in Hawaii, the Bureau broadcasts these five signals: (1) standard radio frequencies; (2) standard audio frequencies; (3) standard time intervals; (4) standard musical pitch; (5) time signals. In addition, radio propagation forecasts are given at stated intervals.

Reference, Working, and Local Standards

Reference standards, derived from these national standards, are used to establish working standards for everyday use.

The local laboratories (lower half of the chart in Fig. 1) also may have three orders of standards—reference, working and shop. The first are reference standards which are used only occasionally so as not to impair their accuracy. Working standards are derived from these reference standards, and are used to calibrate the shop standards that are employed to monitor production and check operating instruments.

One basic problem is the loss of accuracy with each standard that intervenes between the national standard and the standard used in the end operation.

Local Standardization Laboratory Requirements

Space ● A standards laboratory requires controlled temperature and humidity, freedom from vibration, and a clean atmosphere. The temperature control required is usually more precise than that provided in commercial installations of air conditioning for comfort. It may be necessary to put a room or rooms provided with precise controls within a larger space that is also air conditioned, but with less precise controls. However, for many calibrations and tests, humidity need be controlled only to the extent of keeping it below 50%.

Freedom from objectionable vibrations can be assured in many instances by locating the laboratory on the ground and isolating the floor from the rest of the building. In the extreme case, however, it may be desirable to construct a special floor slab and mount it on vibration dampers designed to absorb vibrations of the frequencies likely to be encountered.

Advance planning for the location of each instrument in a standards laboratory may obviate serious difficulties later. In some laboratory plans that have come to the attention of the Bureau, the failure to

Presented at the North Central Automation Symposium of the Instrument Society of America at St. Paul, Minnesota, on January 17, 1958.

make a layout of instruments in advance of providing the space has resulted in a laboratory too small to accommodate the intended operations.

Economy of space can, of course, be effected by setting up instruments and other standards only when they are to be used. Ordinarily, however, any such saving will be much more than offset by the additional labor cost, to say nothing of the possibility of error by failure to make all the necessary adjustments each time the equipment is set up.

Personnel ● A major problem is that of providing adequate staff. Training for a responsible position in a standards laboratory usually is obtained on the job, but the practical experience must be supplemented by extensive reading and study. Technicians skilled in manipulative operations can be employed in standards laboratories for taking observations, but the work of a standards laboratory usually presents a wide variety of day-to-day problems, many of which require judgment or understanding of the principles involved in the measurement. It may be necessary to recruit able young people and arrange for their training at universities where pertinent courses and research are offered, or to detail them for a time to existing standards laboratories.

Recruitment is in competition with the more glamorous areas of science; steps need to be taken to establish the prestige of this type of work. Those who deprecate the importance of determining the next decimal place need to be reminded that future mass production and automation require standards of measurement that are continually being improved.

Equipment ● The Bureau has not published itemized lists of the equipment needed for each type of laboratory because of the variety of requirements of local laboratories. Advice usually given is to employ competent personnel and give them adequate time for study and selection of equipment for the necessary calibrations and tests. This study will usually include visits to other laboratories engaged in similar work and to the Bureau.

Some lists of equipment recommended for specific types of laboratories are to be found in the literature. Kidwell* has prepared such a list for a reference standards laboratory of a large manufacturer of precision equipment. It should be borne in mind that in many cases equally good alternative items are available from manufacturers other than those listed. [The lists in this issue also should help those planning standards laboratories.—Ed.]

NBS Services

The Bureau's primary service to local laboratories is that of calibrating the interlaboratory standards which the local laboratories send to Washington or Boulder. Fees are charged for this service according to a schedule published in the Federal Register. The standards of time and frequency require only an appropriate radio receiver.

Certain standards are provided through the use of properties of pure materials. For example, a very practical and accurate standard of length* is afforded by the wave length of the green line of mercury 198. The Bureau prepares this isotope of mercury using the facilities of the AEC at Oak Ridge, and makes up and sells the lamps to standards laboratories that require them.

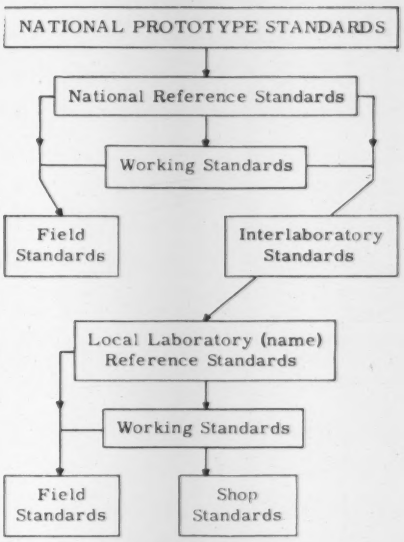


FIG. 1. SCHEME FOR classification of prototype standards.

In the case of *temperature measurements* the Bureau provides pure materials having certified freezing points and, in addition, calibrates temperature-measuring instruments such as platinum resistance thermometers, thermocouples, optical pyrometers, and liquid-in-glass thermometers.

The local laboratories must use standards and apply them to practical work situations. In this the local laboratories frequently need information as to methods, procedures, and techniques. When the information is not available in textbooks or other sources, appropriate publications are issued by the Bureau. These publications range from handbooks designed for relatively inexperienced inspectors of weights and measures, to circulars dealing with subjects such as mass standards, the testing of hydrometers, and methods of determining the resolving power of photographic lenses.

A general type of publication on laboratory practices is the Circular C578 by Silsbee on *Suggested Practices for Electrical Standardizing Laboratories*. (Available from U. S. Gov. Printing Office, 15 cents).

When a new laboratory is being planned or equipped the technical persons concerned can come to Washington or Boulder for first-hand discussions with the Bureau staff members best qualified to provide necessary information and advice.

*"Equipment for a Standards Laboratory," *INSTRUMENTS AND AUTOMATION*, Volume 30, No. 11, pages 2066-2072, November, 1957.

*A proposal is being developed to change the international standard of length from the meter bar at the International Bureau to the wave length of the orange line of krypton 86.

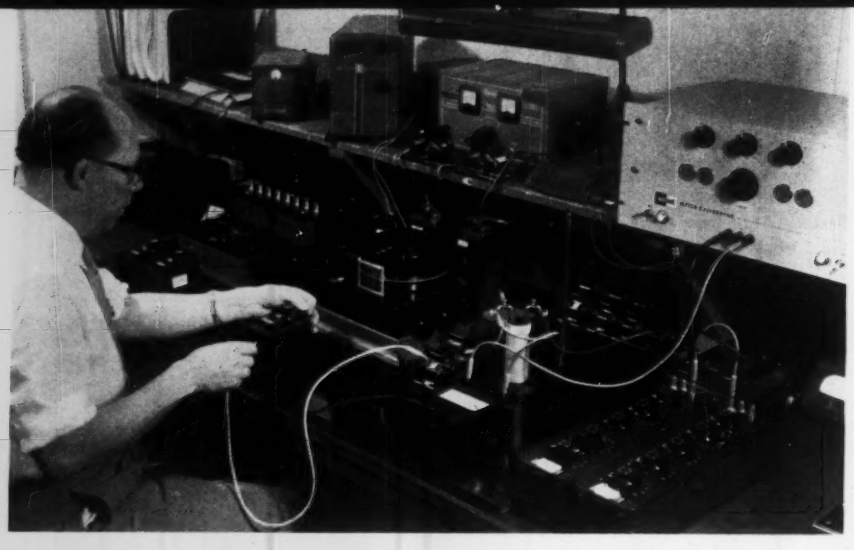


FIG. 1. POTENTIOMETER calibration.

Most industrial and research organizations have large numbers of electrical indicating instruments that must be calibrated and serviced. A properly equipped and operated standardization laboratory is the answer. Here is the step-by-step procedure for starting and equipping a standards laboratory. Tables list actual equipment selected from one such laboratory.

SETTING UP A

FIRST STEP in setting up a standardization laboratory is to organize a maintenance program for all the electrical indicating instruments in the organization that are to be serviced. Adequate records are a must.

Separate records should be kept on each instrument. A card file is practical.

Information on each instrument should include: Type of instrument, manufacturer and model number, manufacturer's serial number, company asset number (if such a system is used), where the instrument normally is used or kept and date acquired.

The service history of each instrument is kept on the cards. An entry is made at each periodic service, standard calibration, and failure in service. This entry should include date, number of tubes replaced and identity of socket, other part replacements and identification from schematic, adjustments and calibration, and remarks or complaints from user. Labor costs or other charges can be recorded also.

A schedule should be made up to insure that each instrument is serviced at proper intervals and is not omitted from the preventive maintenance routine. Different types of instruments require service at different intervals. A color code added to the service history card simplifies scheduling problems. Instruments needing quarterly maintenance and calibration can be staggered by months.

The next item of business is to select equipment to standardize and calibrate these instruments.

Portions of this article are abstracted from IRE-PGI *Transactions on Instruments*, Vol. I-6, No. 2, June, 1957.

Standards for D-C Voltage

The first type of standardization set up is *direct current*. The bible of d-c standardization is a *potentiometer* (Fig. 1). The potentiometer is an accurately calibrated long slidewire; a standard cell is used as a reference voltage for accurate d-c potential measurements, and any unknown potential to be measured is compared on the slidewire to some fraction of the standard cell voltage.

A *voltbox* is used with the potentiometer for measuring potentials which are higher than the fundamental range of the potentiometer (Example: The Type K-2 has a range of up to 1.61 volts). The voltbox consists of a number of accurately standardized resistors connected in series. The potentiometer measuring circuit is connected across one of these resistors and measures its potential drop. The known ratio of the resistors in the voltbox is then used as a multiplying factor to obtain the potential applied to the voltbox. A typical voltbox has ranges of 3, 7.5, 15, 30, 75, 150, 300 and 750 volts maximum.

Equipment for Direct Current

Complete sets of *standard resistors* and *standard shunts* are necessary for accurate current measurement by potentiometer. This includes a multirange shunt for 0.075, 0.15, 0.3, 0.75, 1.5, 3 and 7.5 amps, a 100-ampere shunt (0.01 ohm), and a 15-ampere shunt (0.1 ohm). The shunts are used for d-c measurements (75 ma to 100 amperes) and also for secondary resistance standards. A complete range of standard

FIG. 2. SET of electrodynamometers.

STANDARDIZATION LABORATORY

PHILIP GREENSPAN
JAMES REECE
Motorola Incorporated

resistors (1, 10, 100, 1000, 10,000 and 100,000 ohms) is required for accurate current measurement and resistance calibration in the lower ranges (1 microampere to 1.0 ampere).

The resistance standards, shunts, and standard cells must be sent to the National Bureau of Standards for recalibration and certification at least once a year. The NBS will certify standard cells at an accuracy of 0.01%, and resistance standards at 0.01%. (In using the Type K potentiometer the best accuracy that can possibly be obtained is 0.01%, which is the accuracy to which the NBS will certify the standard cell.) Knowing the actual values of your resistance standards from the NBS certification, then a microammeter, milliammeter, or ammeter can be placed in series with the standard resistor and calibrated to an accuracy of better than 0.1% by measuring the voltage drop across the resistor with the potentiometer. Knowing the resistance and the voltage, the current is easily solved.

A galvanometer and an ayrton shunt for galvanometer damping are necessary for use with the potentiometer (Fig. 1). The galvanometer must be chosen with consideration for the sensitivity required in balancing the potentiometer and the amount of resistance in the galvanometer circuit.

A-C Standards

The potentiometer, voltbox, resistors, shunts, standard cells, and galvanometers are the basic electrical d-c standards; it is necessary to have instruments which indicate alternating current with equal accuracy in order to derive an a-c standard from them. Such instruments are known as *transfer standards* because they can be standardized on direct current and used on alternating current with the same accuracy.

Although both electrodynamometer-type and thermocouple-type instruments can be used as transfer standards, the electrodynamometer type is preferable for precision measurements at the lower frequencies. (Moving-iron instruments, although useful on alternating current, are not as accurate on direct current, and therefore are not suitable for transfer instruments because they cannot be checked directly against a potentiometer and standard cell.) Therefore, a complete set of *electrodynamometers* (0.5 to 1000 volts, 100 ma to 50 amperes) is required for standardization of a-c and d-c instruments (Fig. 2).

For calibration of secondary standard meters and also VTVM's above the audio-frequency range (20 kc) and up to frequencies of approximately 300 Mc, the potentiometer again can be used with external circuit modification as follows:

1. *Power substitution*—In this method *bolometers* (element whose resistance depends on its temperature) are used. The technique assumes that the same temperature (heating effect) is produced by an equal amount of power whether produced by radio frequency or by direct current, and that the resistance of the bolometer element is independent of frequency and reliably dependent on its temperature.

2. *Resistor in series with current-measuring device.* In employing this method to obtain accuracies of about 1%, the d-c calibration of the current-indicating device and the value of the series resistor must be known to 0.5%. Frequency changes in current indication or resistance should be negligible (or small and known

so that corrections can be applied).

A potentiometer is used normally in standardizing meters to high frequencies. By producing the same heating effect at radio frequencies as we do with dc through a thermocouple, resistor, or bolometer, high accuracies are obtained as long as the dc is measured accurately.

Other equipment that is normally included in a standardization laboratory are mentioned below and listed in the accompanying tables.

1. *Precision power supplies*, both voltage and current, dc and ac, for setting test voltages and current on instruments being calibrated.

2. *Signal generators* for frequencies from 100 cps to several kmc for calibration purposes.

3. *Wheatstone and megohm bridges*, used for accurate resistance calibration.

4. *Capacitance and inductance bridges*, used for standardization of inductors and capacitors.

5. A *frequency standard*, a good *receiver*, and a *frequency counter* for calibration of oscillators and signal generators and for time measurement.

6. A *time-mark generator* for calibration of sweeps and oscilloscopes.

7. *Power bridges* and *wattmeters*, used to calibrate other bridges and wattmeters in the organization.

8. A *good oscilloscope* to observe waveforms and pulses.

9. A *standard thermocouple bridge* or *potentiometer* to calibrate temperature-indicating instruments from −100°C to +500°C.

10. A *barretter bridge* for the precise measurement of signal generator outputs in the frequency range from 2 to 1000 Mc.

Some companies do not need such an elaborate standardization laboratory or program; some may need only resistance calibrating equipment, others only capacitance, etc. Motorola, because of its vast number of products produced and the extreme range of frequencies covered, needs all of the equipment mentioned to insure that all voltmeters, ammeters, and wattmeters, whether on the production line or in engineering development, read the same whether on dc or 1000 Mc.

The equipments listed on Table 1 to 14 make this possible.

In the tables the following abbreviations are used:

Biddle-J = Biddle Jagabi
B-K = Bruel Kjar
E-A = Esterline-Angus
FTR = Federal Telephone & Radio
G-R = General Radio
H-P = Hewlett-Packard
L&N = Leeds & Northrup
P-R = Physics Research
Sens-Research = Sensitive Research
S-P = Specific Products
Tek = Tektronix
W-E = Western Electric

[The mention of company name should not be considered an endorsement; similar equipments are available from other sources, as listed in the *I&A* 1959 Buyers' Guide under appropriate headings—Ed.]

TABLE 1—GENERAL EQUIPMENT STANDARDS LABORATORY

Qty	Standard or Accessory	Range	Accuracy	Cal. Int. (mo.)
1	Sens.-Research Universal 88	0-750 vac-dc 0-1500 mils ac-dc 0-3 amps ac	½% dc, ¾% ac	3
1	Impedance Bridge Electro-Measurements Mod. 250DA	0.1 milliohm to 12 megohms; 0.1 mmfd to 1200 mfd; 0.1 microhenry to 1200 henry	0.1% 0.25% 0.9%	12
1	Multimeter Millivac MV-73B VTVM	1 mv to 1000 vac; 1 mv to 1000 vdc; 1 mv to 1000 vrf; 0 ohms-2000 megohms; 0 microamps to 10 amp, ac-dc	4% 3% 5% 4%	3
1	Transconductance Analyzer New London 901A	all tubes	——	12
1	Sweep Drive G-R 1750-A	——	——	12
1	Microwave Panoramic Analyzer Motorola P8981	——	——	12
1	Variable a-c Regulated Voltage Supply	0 to 1500 v	——	3
1	Variable a-c Regulated Current Supply	0 to 60 amps	——	3
1	Regulated d-c Supply Perkins 6-40WXM	6v, 50 amps	——	3
2	Carbon Piles Biddle #10	0.06 to 6 ohms, 250 watts	——	——
1	Carbon Pile Biddle #20	0.04 to 4 ohms, 1000 watts	——	——
1	Rheostat Biddle-J.	15980 ohms, 0.1 amps	——	——
1	Rheostat Biddle-J.	7250 ohms, 0.2 amps	——	——
1	Rheostat Biddle-J.	7900 ohms, 0.2 amps	——	——
1	Rheostat Biddle-J.	1535 ohms, 0.5 amps	——	——
1	Rheostat Biddle-J.	1560 ohms 0.5 amps	——	——
1	Rheostat Biddle-J.	606 ohms 1.0 amps	——	——
1	Rheostat Biddle-J.	607 ohms 1.0 amps	——	——
1	Rheostat Biddle-J.	100 ohms 2.3 amps	——	——
1	Rheostat Biddle-J.	78 ohms 2.8 amps	——	——
1	Rheostat Biddle-J.	15 ohms 6.5 amps	——	——
1	Rheostat Biddle-J.	4.5 ohms 12 amps	——	——
1	Rheostat Biddle-J.	4.6 ohms 12 amps	——	——
2	Rheostat Biddle-J.	1.2 ohms 20 amps	——	——
2	Rheostat Biddle-J.	0.9 ohms 25 amps	——	——
1	VTVM H-P 410B	0-300 vac 0-1000 vdc 0-500 megs	3%	3
1	AC Line Regulator Sorensen 1001	110-120 vac 1000 va	0.01%	3
3	Communication Receivers Motorola	25-50 Mc 144-174 Mc 450-470 Mc	——	——
2	Recorders E-A Model AW	——	——	——
	Receiver National HR060-T	50 kc-50 Mc	——	——

TABLE 2—STANDARDS OF FREQUENCY AND TIME PRIMARY STANDARDS LABORATORY

Qty	Standard or Accessory	Range	Accuracy	Cal. Int. (days)
1	WWVR Receiver S-P	5-10-15 Mc 440-600-1000 cps	Absolute	NBS daily
1	Frequency Counter Berkeley 5571	0-42 Mc	±1 count	30
1	Converter Berkeley 5580	42-515 Mc	1 part in 10^7, ±1 cycle	30
1	Selective Amplifier Berkeley 5585	2-42 Mc		90
1	Plug-in Berkeley 5581/4	42-155 Mc	1 part in 10^7, ±1 cycle	30
1	Plug-in Berkeley 5581/15	152-185 Mc	1 part in 10^7, ±1 cycle	30
1	Plug-in Berkeley 5581/44	398-482 Mc	1 part in 10^7, ±1 cycle	30
1	Frequency Converter H-P 524B	10 cps-10 Mc	2 ppm/ week	NBS daily
1	Frequency Standard Norman Labs 110A	1 cps-1 Mc	1 part in 10^9	NBS daily

TABLE 3—STANDARDS OF FREQUENCY AND TIME SECONDARY STANDARDS LABORATORY

Qty	Standard or Accessory	Range	Accuracy	Cal. Int. (mo.)
1	Oscilloscope Dumont 304H	Dc-30 kc	——	1
1	Oscilloscope Tek. 531	Dc-10 Mc	——	1
1	Preamp Tek. 53 B	Dc-10 Mc	——	3
1	Preamp Tek. 53C	Dc-10 Mc	——	3
1	Square-Wave Generator Tek. 105	25 cps-1 Mc	3% of full scale	3
1	Constant-Amplitude Sig. Gen. Tek. 190	350 kc-50 Mc	2%	3
2	Audio Generators H-P 200C	20 cps-200 kc	2%	3
1	Audio Generator H-P 200CD	5 cps-600 kc	2%	3
1	Test Oscillator H-P 650A	10 cps-10 Mc	2% from 10 to 100 cps 3%, 100 cps-10 Mc	3
1	Frequency Meter Gertsch FM-3	20-640 Mc	0.001%	3
1	Signal Generator H-P 608C	10-480 Mc	0.5%	1
1	Signal Generator H-P 612A	450-1230 Mc	1.0%	1
1	Signal Generator Marconi TF1066/1 AM/FM	10-470 Mc	1.0%	1
1	Power-type Signal Gen. Rollin 30	40.7-400 Mc	1.0%	3

TABLE 4—STANDARDS OF VOLTAGE, AC AND DC PRIMARY STANDARDS LABORATORY

Qty	Standard or Accessory	Range (v)	Accuracy	Cal. Int. (mo.)
1	Potentiometer L&N K2	0-1.6	0.01%	6
1	Volt Box L&N Model 7591	3-7.5-15-30-150-300-750	0.04%	12
1	Galvanometer L&N Model 2430	——	——	——
1	Galvanometer L&N Model 2420	——	——	——
3	Ballistic Galvanometers Winslow	——	——	——
2	Std. Cells Sens. Research	1.0194	0.01%	12
4	Std. Cells Eppley Model 100	1.0194	0.01%	12
1	Absolute d-c Power Supply Kin Tel 508-100	1.02 to 501	0.02%	3
1	AC Meter Calibrator Sorensen VRSAC-751	1 to 799	0.1%	3

TABLE 5—STANDARDS OF VOLTAGE, AC AND DC SECONDARY STANDARDS LABORATORY

Qty	Standard or Accessory	Range	Accuracy	Cal. Int. (mo.)
1	Electrostatic Voltmeter Sens.-Research Model ESD	0-3000 v	1.0%	3
1	Millivoltmeter Sens.-Research Model S	0-3, 0-10 mv	0.5%	3
1	Expanded-scale a-c Voltmeter Shasta 101-50	50 to 250 v	0.25%	3
1	A-c/d-c voltmeter Weston Model 341	0-1.5 v 0-3.0 v	0.5%	3
1	A-c/d-c voltmeter Weston Model 341	0-15 v 0-30 v	0.25%	3
1	A-c/d-c voltmeter Weston Model 341	0-150 v 0-300 v 0-750 v	0.25%	3
1	D-c Millivoltmeter Weston Model 622	0-1, 10, 50 200, 1000 mv	0.5%	3
1	D-c Millivoltmeter Weston Model 622	0-2, 5, 10, 20 50 mv	0.5%	3
1	D-c Millivoltmeter P-R	0-12, 30, 60 mv	1.0%	3
1	D-c Voltmeter P-R	0-3, 12, 60 v	0.5%	3
1	D-c Voltmeter P-R	0-6, 30, 300 v	0.5%	3
1	Capacitive Voltage Divider H-P 452A	0-25 kv	3.0%	12

TABLE 6—STANDARDS OF ELECTRICAL CURRENT PRIMARY STANDARDS LABORATORY

Qty	Standard or Accessory	Range	Accuracy	Cal. Int. (mo.)
1	Potentiometer L&N K2	0 to 1.6 v	0.01%	12
1	Shunt L&N Model 4360	0.1 ohm, 15 amps abs.	0.04%	3
1	Shunt L&N Model 4361	0.01 ohm, 100 amps abs.	0.04%	3
1	Shunt L&N Ayrton Model 2116	10000 ohms X 1, 0.1, .01, .001, 0 and infinity	0.1%	3
1	Shunt Box L&N Model 4390	0.075-0.15-0.3, 0.75-1.5-3 7.5 amps	0.04%	3

TABLE 7—STANDARDS OF ELECTRICAL CURRENT, AC AND DC SECONDARY STANDARDS LABORATORY

Qty	Standard or Accessory	Range	Accuracy	Cal. Int. (mo.)
1	Milliammeter Weston Model 370	0-15, 30	0.25%	3
1	Milliammeter Weston Model 370	0-75, 150	0.25%	3
1	Ammeter Weston Model 370	0-0.5, 1.0	0.25%	3
1	Ammeter Weston Model 370	0-2.5, 5.0	0.25%	3
1	Ammeter Weston Model 370	0-10, 20	0.25%	3
1	D-c Ammeter Rawson Model 501	0-100	0.5%	3
1	D-c Microammeter Greibach Model 500	0-1, 3, 10, 30 100, 300, 1000	0.25%	3
1	D-c Microammeter P-R	0-60	0.5%	3
1	D-c Milliammeter P-R	0-0.6, 3, 12	0.5%	3
1	D-c Milliammeter P-R	0-6, 30, 120	0.5%	3
1	A-c Milliammeter P-R	0-0.6	1.5%	3
1	A-c Milliammeter P-R	0-3	1.5%	3
1	A-c Milliammeter P-R	0-30	1.5%	3
1	A-c Milliammeter P-R	0-3, 12, 60	1.5%	3
1	A-c Milliammeter P-R	0-120, 600	0.5%	3
1	A-c Ammeter P-R	0-1.2, 6	0.5%	3
1	A-c Ammeter P-R	0-3, 12	0.5%	3
1	A-c Ammeter P-R	0-6, 30	0.5%	3
1	Thermojunction Sensi.-Research	5 ma	0.5%	12
1	Thermojunction Sensi.-Research	25 ma	0.5%	12
1	Thermojunction Sensi.-Research	50 ma	0.5%	12
1	Thermojunction Sensi.-Research	75 ma	0.5%	12
1	Thermojunction Sensi.-Research	200 ma	0.5%	12
1	Thermojunction Sensi.-Research	5 amp	0.5%	12

TABLE 7—Continued from left column

1	Thermojunction Box Sensi.-Research	0-2, 10, 50, 100, 500 ma	0.5%	12
1	Portable Shunt 50 mv Weston	10 amp	0.5%	—
1	Portable Shunt 50 mv Weston	15 amp	0.5%	—
1	Portable Shunt 50 mv Weston	25 amp	0.5%	—
2	Portable Shunt 50 mv Weston	50 amp	0.5%	—
1	Portable Shunt 50 mv Weston	75 amp	0.5%	—
1	Portable Shunt 50 mv Weston	100 amp	0.5%	—

TABLE 8—STANDARDS OF RESISTANCE STANDARDS LABORATORY

Qty	Standard or Accessory	Range (ohms)	Accuracy	Cal. Int. (mo.)
2	Resistance Decades 1432-N G-R	0.1 to 11111	0.05%	12
1	Resistance Decade 1432-P G-R	10 to 1111100	0.05%	12
1	Resistor 500-A G-R	1	0.15%	12
1	Resistor 500-B G-R	10	0.05%	12
1	Resistor 500-C G-R	50	0.05%	12
1	Resistor 500-D G-R	100	0.05%	12
1	Resistor 500-E G-R	200	0.05%	12
1	Resistor 500-F G-R	500	0.05%	12
1	Resistor 500-G G-R	600	0.05%	12
1	Resistor 500-H G-R	1000	0.05%	12
1	Resistor 500-M G-R	5000	0.05%	12
1	Resistor 500-J G-R	10000	0.05%	12
1	Resistor 500-R G-R	20000	0.05%	12
1	Resistor 500-T G-R	50000	0.05%	12
1	Resistor 500-U G-R	100000	0.05%	12
1	Resistor L & N Cat. 4020-B	1	0.01%	12
1	Resistor L&N Cat. 4025-B	10	0.01%	12
1	Resistor L&N Cat. 4030-B	100	0.01%	12
1	Resistor L&N Cat. 4035-B	1000	0.01%	12
1	Resistor L&N Cat. 4040-B	10000	0.01%	12
1	Resistor L&N Cat. 4632	2000	0.1%	12
1	Resistor L&N Cat. 4631	1000	0.1%	12
1	Resistor L&N Cat. 4640	10000	0.1%	12
1	Resistor Otto Wolff	0.001	0.01%	12
1	Resistor Otto Wolff	1.0	0.01%	12
3	Resistors Otto Wolff	100.0	0.01%	12
1	Resistor Otto Wolff	100000.0	0.01%	12
1	Wheatstone Bridge Rubicon Model 1050	0.001 to 10 Megohms	0.05%	12
1	Kelvin Bridge L&N Model 4286	0.0001 to 11	0.2%	12
1	Wheatstone Bridge L&N Model 5300	0.001 to 10 Meg	0.05%	12
1	Comparison Resistor FTR	1000 Meg	10%	12
1	Comparison Resistor FTR	10000 Meg	10%	12
1	Comparison Resistor FTR	100000 Meg	10%	12

TABLE 9—STANDARDS OF INDUCTANCE STANDARDS LABORATORY

Qty	Standard or Accessory	Range	Accuracy	Cal. Int. (mo.)
1	Q Meter Boonton 160A	50 kc to 75 Mc	5%	3
1	Q Meter Boonton 260A	50 kc to 50 Mc	1%	3
1	Set Q Standards Boonton 103A	0.1 uh to 52 mh	2%	12
1	Set Inductance Standards Boonton 590A	0.05 uh, 2.5 uh	——	12
1	RX Meter Boonton 250A	0.5 to 250 Mc	1.0%	12
1	Inductor G-R 1481-A	1 mh	1%	12
1	Inductor G-R 1481-B	2 mh	1.0%	12
1	Inductor G-R 1481-C	5 mh	0.5%	12
1	Inductor G-R 1481-D	10 mh	0.5%	12
1	Inductor G-R 1481-E	20 mh	0.5%	12
2	Inductor G-R 1481-F	50 mh	0.5%	12
1	Inductor G-R 1481-G	100 mh	0.25%	12
1	Inductor G-R 1481-H	200 mh	0.25%	12
1	Inductor G-R 1481-J	500 mh	0.25%	12
1	Inductor G-R 1481-K	1 h	0.25%	12
1	Inductor G-R 1481-L	2 h	0.25%	12
2	Inductor G-R 1481-M	5 h	0.25%	12
1	Inductance Bridge G-R 667A	0.1 uh to 1 h	0.2%	3

TABLE 10—STANDARDS OF CAPACITY STANDARDS LABORATORY

Qty	Standard or Accessory	Range	Accuracy	Cal. Int. (mo.)
1	Capacitor G-R 722MD	0—1050 mmfd 0—105 mmfd	0.1%	12
1	Capacitor G-R 722ME	0—105 mmfd 0—10.5 mmfd	0.1%	12
1	Capacitor G-R 1401-A	100 mmfd	0.1%	12
1	Capacitor G-R 1401-B	200 mmfd	0.1%	12
1	Capacitor G-R 1401-C	500 mmfd	0.1%	12
1	Capacitor G-R 1401-D	1000 mmfd	0.1%	12
1	Capacitance Bridge G-R 761C	100 mmfd to 1 mfd	0.1%	12
1	Capacitor G-R 505-B	200 mmfd	0.5%	12
1	Capacitor G-R 505-E	500 mmfd	0.5%	12
1	Capacitor G-R 505-F	0.001 mfd	0.5%	12
1	Capacitor G-R 505-G	0.002 mfd	0.5%	12
1	Capacitor G-R 505-K	0.005 mfd	0.5%	12
1	Capacitor G-R 505-L	0.01 mfd	0.5%	12
1	Capacitor G-R 505-M	0.02 mfd	0.5%	12
2	Capacitor G-R 505-R	0.05 mfd	0.5%	12
1	Capacitor G-R 505-T	0.1 mfd	0.5%	12
1	Capacitor G-R 505-U	0.2 mfd	0.5%	12

TABLE 11—STANDARDS OF POWER, AC STANDARDS LABORATORY

Qty	Standard or Accessory	Range	Accuracy	Cal Int. (mo.)
1	Wattmeter Weston Model 432	150/75 watts	0.5%	(mo.) 3
1	Power Bridge W-E 70A	dc to 10 Mc		3

TABLE 12—STANDARDS OF POWER, RF STANDARDS LABORATORY

Qty	Standard or Accessory	Range	Accuracy	Cal. Int. (mo.)
1	Calorimeter M. C. Jones 641N	0-3000 Mc. 0-300 watts	2%	3
1	Calorimeter Lab-built	0-3000 Mc 0-300 watts	2%	3
1	Power Bridge H-P 430C	10 Mc-10 kmc 0.02-10 mw	5%	3
1	Barreter Bridge Measurements 202B	2 Mc-1000 Mc	5%	3
1	R-f Voltage Standard Boonton 245B	0.1 Mc- 1000 Mc	10% to 500 Mc	3
3	Comm. Transmitters Motorola	25-50 Mc 144-174 Mc 450-470 Mc	——	——
1	Wattmeter with Set of Elements, Bird Thruline	25-1000 Mc 0-100 watts	5%	1
1	Slotted Line G-R 874LBA	300-5000 Mc	——	——

TABLE 13—STANDARDS OF TEMPERATURE STANDARDS LABORATORY

Qty	Standard or Accessory	Range	Accuracy	Cal. Int. (mo.)
1	Electric Oven Tempco GRP	0 to 1000°C 0 to 2000°F	——	——
1	Millivolt Indicator L&N Model 8667	0 to 111 mv	0.1 mv.	3
1	Potentiometer L&N K2	0 to 1.6 v	0.01%	12
2	Thermometers, H-B Instruments	+0° to +205°C	——	12
2	Thermometers Taylor	−30° to +120°F	——	12
1	Thermometer Taylor	−2° to +80°C	——	12
2	Thermometers Taylor	−38° to +42°C	——	12
1	Thermometer Taylor	−2° to +52°C	——	12
2	Thermometers Taylor	+24° to +78°C	——	12
2	Thermometers Taylor	+48° to +102°C	——	12
1	Thermometer Taylor	+72° to +126°C	——	12
1	Thermometer Taylor	+98° to +158°C	——	12
1	Temperature Recorder Brown	——	——	3

TABLE 14—STANDARDS OF AUDIO STANDARDS LABORATORY

Qty	Standard or Accessory	Range (cps)	Accuracy	Cal. Int. (mo.)
1	BFO B-K Type 1014	20-20000	1%	3
1	Microphone Amplifier B-K 2601	20-20000	±0.5 db	3
1	Level Recorder B-K 230-	20-20000	——	3
1	Condenser Microphone B-K 4111	20-10000	±1½ db	3
1	Condenser Microphone B-K 4111	30-8000	±1½ db	3
1	Artificial Voice B-K	100-3000	±0 db	3
1	Artificial Ear B-K	100-3000	±0 db	3
1	Anechoic Sound Chamber, Eckel	6' x 6' x 6', 250 cps	——	——

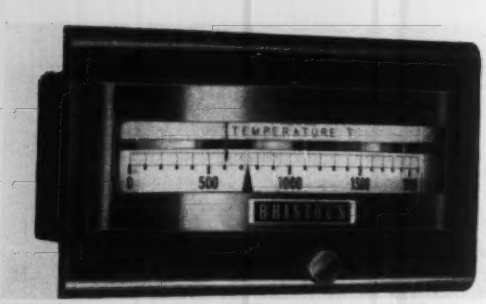


FIG. 1. MILLIVOLTMETER pyrometer. (Courtesy The Bristol Co.)

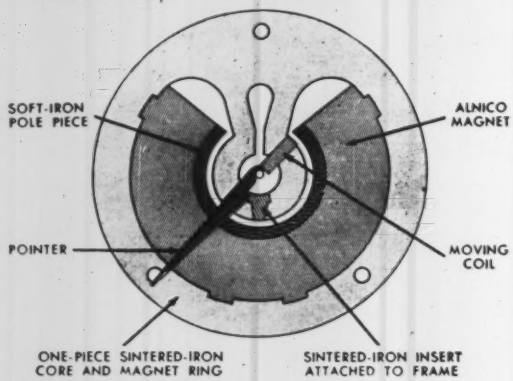


FIG. 2. PRINCIPLE OF the long-scale instrument. (Courtesy General Electric)

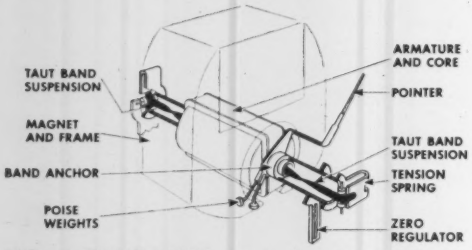


FIG. 3. TAUT-BAND suspension is considered to be an outstanding innovation. (Courtesy Hickok Electrical Instrument Co.)

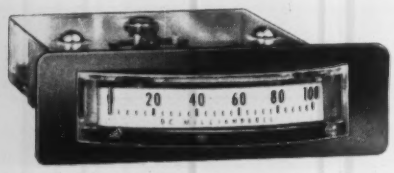


FIG. 4. MILLIVOLTMETERS and milliammeters are available in many panel styles including this miniature model. (Courtesy Simpson Electric Co.)

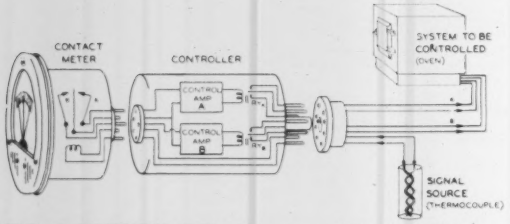


FIG. 5. UNITIZED RELAY system. (Courtsey Waters Mfg. Co.)

Refinements of Basic

SEVERAL REFINEMENTS in basic electrical movements deserve special mention. These include the many styles of panel indicators, the long-scale instrument, hook-on ammeters, and the contact-meter relay.

Panel Indicators

One important use of the direct-reading millivoltmeter is as a pyrometer, connected directly to a thermocouple (Fig. 1).

The long-scale instrument differs from the conventional type in that it has only one pole face instead of two, allowing 250 degrees rotation of the coil (Fig. 2). Moreover, the moving coil is pivoted on one side instead of in the center and only one side of the coil is effective in producing torque. The magnet of the long-scale instrument is sector-shaped, and is cast integrally with a soft steel pole face for uniform distribution of flux in the air gap.

The taut-band suspension (Fig. 3) is considered by many to be "most outstanding innovation in a decade." The suspension comprises thin metal strips that support the movement, carry the current, and provide the restoring torque. Advantages are (1) elimination of conventional bearing-pivot-hairspring element, (2) increase in sensitivity so that ½-microampere movements are possible with 100-angular-degree deflection and power consumption below 10^{-8} watt, (3) increased ruggedness. This is a remarkable combination of advances.

Another innovation is the Bar-Ring* p-m m-c construction wherein a large and strong bar magnet has one pole opposite the coil; the second pole is brought to the other side of the coil via an iron ring that also acts as a shield. The result is high flux density with self-shielding.

Refinements in style, illumination, size, etc., have been made recently in panel meters. The reader is referred to the advertised products on pages 61 (General Electric), 66 (Beede), 124 (Hickok), 137 (Marion), 145 (Assembly Products) and 148 (Moser).

*Triplett Electrical Instrument Co. (see page 27).

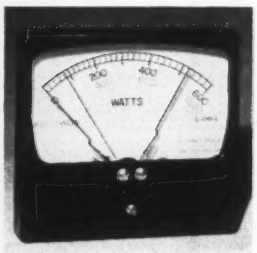


FIG. 6. LOCKING CONTACT wattmeters. (Courtesy Assembly Products)

Electrical Movements

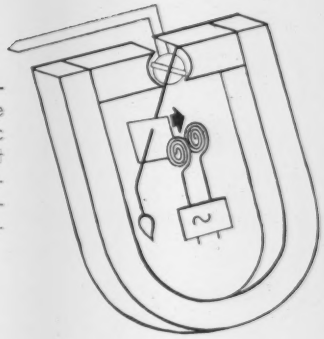


FIG. 8. PYR-O-VANE controllers use vane on p-m m-c movement to effect control action. (Courtesy Minneapolis-Honeywell, Brown Instruments Div.)

Other electrical instrument refinements will be found on pages 2 (Sensitive Research), 9 (Radio Frequency Labs), 41 (Cambridge), 44 (Greibach), 120 (Stevens Arnold), 122 (Gray), 128 (Acton), 144 (Trio) and 154 (Freed).

Contact Meter Relays

The combination of a p-m m-c movement and contacts comprises a simple and versatile controller.

Fig. 5 shows a unitized meter-relay system that features a transistorized self-contained unit with no locking coils or magnetic contacts. Reset is automatic.

Most recent developments in the contact-meter field include a locking-contact wattmeter (Fig. 6) and the "differential" meter-relay (Fig. 7). In the former, a core-magnet contact-meter relay is used with an electrodynamometer movement to control watts directly. In the latter, two moving coils are used instead of the usual one. As the pointer indicates either the sum or difference of the signals in the two coils (as in the differential instrument described previously), one coil can be used to program an operation. A program can be set up by means of timers, cams, punched-tape, etc.

Fig. 8 shows another adaptation of the economic and reliable p-m m-c millivoltmeter to control. Here a lightweight vane on the pointer passes between two coils in an oscillator circuit. When the pointer reaches the set point (established by the position of the coils) the oscillator stops oscillating, causing immediate snap action of a relay. Use of a second vane and coil combination permits varying on-off times, giving effective proportional control.

Hook-On Ammeter

The hook-on ammeter (Fig. 9) is a rectifier-type movement plus a split-core transformer. The core can be closed around a conductor, forming a 1-turn primary winding. The secondary voltage, proportional to current in the conductor, is then measured.

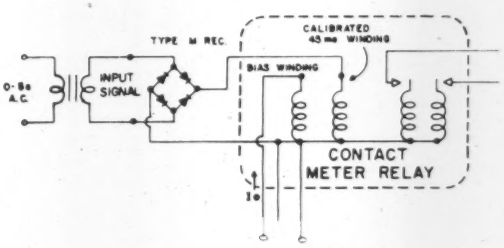


FIG. 7. DIFFERENTIAL RELAY. (Courtesy Assembly Products)

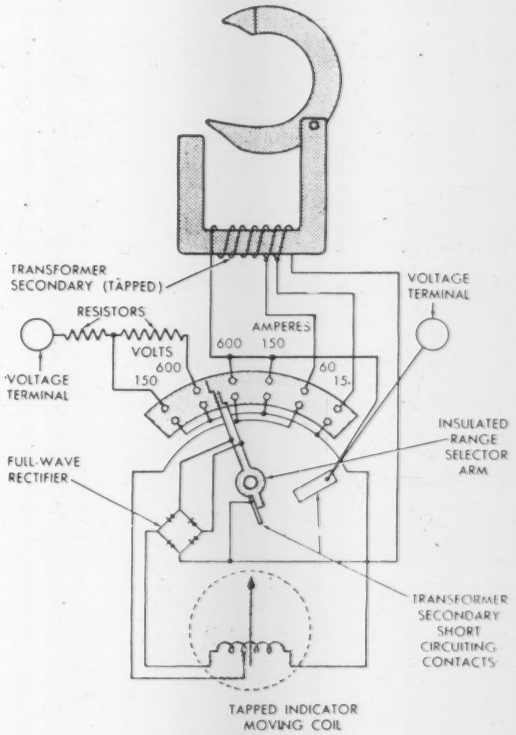


FIG. 9. HOOK-ON AMMETER is normally used between 50 and 70 cps. (Courtesy General Electric)

FIG. 10. USE of a light-beam indicator in a precision instrument to reduce inertia of the movement. (Courtesy Greibach Instruments Corp.)

Soviet Trends in Computers for Control of

A clear and thorough résumé of the state of Soviet computer art, including general-purpose and special-purpose analog computers, network analogs, "programmed and reflection" process control computers, and optimum parameter control computers. This final installment covers process control computers.

Group IV—Computers for Automatic Process Control

Recent research was carried on with the view to utilizing computers for control of multi-high rolling mills, metal working lathes, continuous production lines, electric arc furnaces, complex power systems, trains, retarders on hump yards, blast furnaces, calcinating furnaces, boring machines, textile machinery, chemical plants, aerodynamical pipes, and others.

Computers of this group can be of digital or analog type, or combined analog-and-digital circuits. They are still being studied or under development. There is no doubt, however, in their finding wide application in many fields in the near future for active control of complex processes.

Programmed Process Control Computers

Process control computers can be placed in two categories. In the first are devices for programmed process control; in the second, devices for reflection process control (control by reaction on deviation from preset conditions). In practice, a combination of both types of devices may be possible.

Examples of devices for programmed control include devices controlling the operation of metal working tools or continuous production lines. Such computers already have found wide application, chiefly in governing the actions of one or several machines or industrial units to carry out the design of the product as worked out in drawings or other documents.

Reflection Process Control

The devices for reflection process control are more complicated. They may be subdivided according to (1) preliminary settings, (2) extreme parameters, and (3) optimum parameters.

Each of these types has great practical significance, the "optimum parameters control" devices being the most promising. On the basis of the input information this computer provides for automatic optimal routine decision-making in order to maintain desired technical and economic characteristics. However, the use of this kind of control device with self-adjusting systems is but in the experimental stage of development.

In practice, different combined methods of reflection control are possible. As an example of the application of a computer device with reflection control with preliminary settings, let us consider the so-called "Autodriver," a control computer used for automatic regulation of locomotive traction.

This device (Fig. 9) controls a train at maximum speed in strict conformity with schedule, independent of changes which might occur in the weight of the train, temporary speed limitations, fluctuations of traction motors, amount of wear of wheel rims, variable train resistance (depending on meteorological conditions and state of railway track), and other factors causing disturbance in the traffic over open lines. This automatic control is not yet absolutely perfect because it does not consider factors connected with economic power consumption, the prevention of Diesel and electric motor overheating, and other factors depending on the variation of speed of the train. The main criterion for the control of the train motion by the "Autodriver" is the time schedule, which is the main setting for the entire system.

Operation of the "Autodriver" is based on continuous solution of the equation describing the train motion:

Manufacturing Processes

V. B. USHAKOV
Scientist, Moscow University

FIG. 9. **AUTODRIVER** computer unit.

$$\frac{d^2S}{dt^2} = \zeta\,(f - w - b \pm i)$$

where $\frac{d^2S}{dt^2}$ is the acceleration of the train motion (km/h^2); f is specific tractive effort (kg/t); w is specific train resistance (kg/t); b is specific braking effort (kg/t); i is track slope or elevation gradient; ζ is acceleration under the effect of the force of 1 kg/t (km/h^2).

By solving the equation for the following section of the track, and taking into account the virtual data on the train motion, it is possible to obtain the traction characteristics required for that section of the track. The train motion, the distance travelled, and the virtual speed are inserted from special sensers into the Autodriver circuit as initial conditions.

Simultaneously, the computer takes into account the corrected characteristics of the locomotive and braking arrangements. The factor of train resistance is determined in the computer proper, and data on the curve of the railway track and limitations in relation to speed are introduced in the form of programs. On the basis of the solution obtained, the time necessary for the train to pass across the track section lying ahead is determined.

The logic circuit compares the calculated time against the setting and, provided it is ascertained that the time schedule can be maintained, a command is emitted causing transition to the selected routine at a given moment. The computer device also emits commands determining the train motion if there are limitations in speed in the path or warning signals of automatic interlocking. For designing the pilot unit of the Autodriver (Fig. 10), a circuit with ferrite cores was chosen in which all the variables are expressed in digital form, but are realized by parallel execution of main mathematical operations, as in analog computers.

With the aim of simplifying the circuit and reducing the time required for the computing operations in solving the equation of train motion, the Euler method of digital integrating was adopted. According to this method the differential equation of the train motion is reduced to a set of algebraic equations, as follows:

$$V_{n+1} = V_n + 120\,[f(V_n) + i_n]\,\Delta t$$
$$S_{n+1} = S_n + V_n \Delta t$$

where Δt is the integration step (equal to 0.9 sec); $n + 1$ is the number of integration steps; f (v) is the factor of train resistance; S_{n+1}, V_{n+1} are distance and speed for section lying ahead; i is slope of track.

The steps followed in solving the set of algebraic equations are as follows:

Current values of speed V_o, distance S_o, and train motion time t_o are sent from the locomotive senser into the computer unit.

Next, on the basis of V_o and S_o, separate terms of the algebraic equations are computed and the auxiliary values V_1 and S_1 are determined. Simultaneously the value $t = t_o + \Delta t$ is determined. Next the computation cycle is quickly repeated for the time interval Δt, with the sole difference that instead of V_o and S_o, values V_1 and S_1 are adopted as initial ones. Such cycles are repeated until the value S_{n+1} is equal to the length of the control section lying ahead. Now the computed time is compared against the preset time for the end of the track control section. If the difference in time is positive, a greater traction characteristic is preset and the same computation is repeated. Such tests with

logical comparisons are carried on until there is a reversal in sign of the difference between the computed and the schedule time. When this is achieved, the traction characteristic selected by this method for the engine is adopted for the locomotive, and the moment of transition is recorded.

The same method is used for computing the speed at the end of the selected section.

The model of the Autodriver, having passed the pilot tests on the railways of the Soviet Union in 1957-58, comprises (1) an exterior unit with sensers of speed, path, train motion time, and interlocking signals, (2) computer and control units, and (3) an operating unit and power supplies. The control unit is provided with programs necessary for the functioning of all other units of the Autodriver. The train routine program is set according to computations of traction or on the base of test runs.

The computer unit (Fig. 9) has a summer and two circuits—one for storing and sending traction characteristics and the other for logic decision making. The computer unit calculates the factor of train resistance, and makes necessary corrections, taking into account virtual conditions, and finally determines the most adequate routine for running the train according to the schedule.

The Autodriver is a typical example of prediction control wherein the computer periodically solves an equation at a much faster rate than the process (described by the equations) takes place. On the basis of the results the future performance of the controlled process is "predicated" and an adequate control program for this process is worked out.

The application of the Autodriver on the railways opens new possibilities for more efficient exploitation of transport means. Specialists are of the opinion that the use of such devices will produce an economy of 5 to 7% in locomotive power consumption, and will increase the traffic capacity of the railways by 15 to 20%.

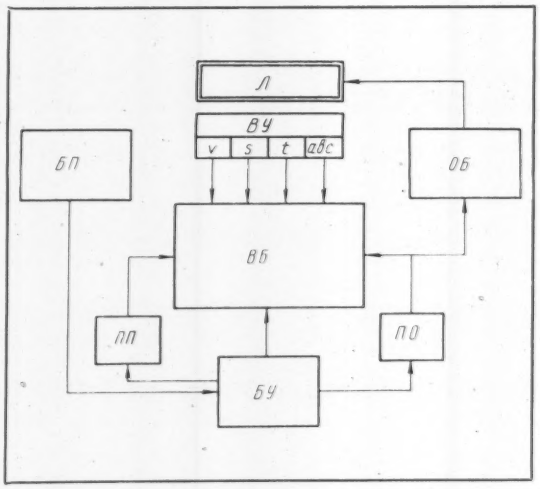


FIG. 10. BLOCK DIAGRAM of Autodriver.

Extreme Parameter Control

Systems of reflection control according to *extreme parameters* automatically maintain the controlled parameter at a maximum or minimum value, and not at a preset value. The use of such systems is limited to processes which, by their nature, have extreme characteristics. Such processes pertain to control of aeroplane motor maximum efficiency (with the view to insure maximum distance of flight with a certain quantity of fuel), maintenance of maximum speed of heading when boring different kinds of rocks (by regulating the pressure exerted by the cutter on the face), control of the heat transfer factor in sugar plant evaporators (by modifying the speed of circulation or the relative level of the sugar juice in the pan), and control of various processes with extreme parameters in different branches of chemistry, power engineering, metal industry, food industry, constructional engineering, etc.

Complex computer devices may not be required in extreme parameter control and only an elementary memory and a simple logic may be required. As an example of efficient application of extreme parameter control, let us consider the problem of controlling the operational routine of a brick kiln (Fig. 11). Here the predetermined temperature is maintained by a common multistep temperature regulator, controlling the quantity of gas fed into the furnace. For maintaining optimum burning conditions in the furnace a certain composition of the gas-air mixture must be provided. The air is fed into the combustion zone of the kiln along a channel, and the air losses (due to leakage through the truck walls, improper sand seals between the trucks, and other factors) cannot possibly be taken into account.

Therefore the kiln maximum temperature at a certain quantity of gas input was adopted as a criterion for an optimum gas-air mixture. An increase in the quantity of gas fed into the kiln (required by new incoming trucks with bricks) automatically brings about an increase in the air feed until the excess of air causes a drop of the temperature. From this point the air feed is decreased. This will cause the temperature to increase slightly and, upon reaching a maximum value, to decrease again, which will result in a new increase of the air feed. The air feed will fluctuate about the extreme point until the temperature regulator moves to the following step—if the temperature has not reached its predetermined value. Now the air feed will increase again until the new extreme value is attained. Such a stepwise approach of the extreme to the preset temperature value is illustrated in Fig. 11.

The air feed is controlled by the *extreme regulator*, which maintains an optimum air-gas relation in the combustion zone. The relay-operated electronic regula-

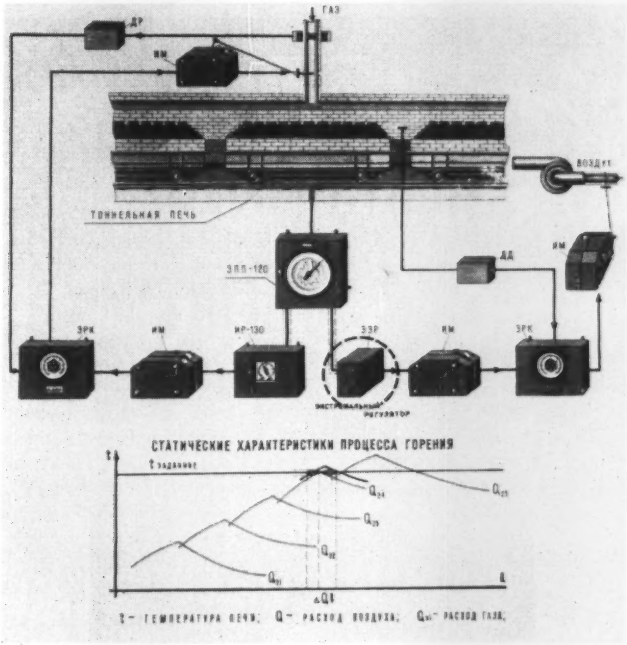


FIG. 11. DIAGRAM and schedule of brick kiln.

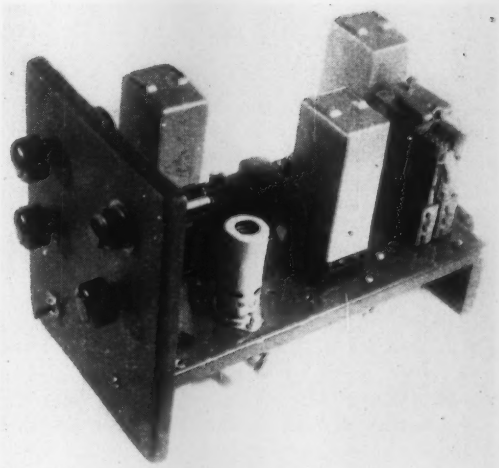


FIG. 12. AN EXTREME regulator.

tor, installed on the brick kiln (see Fig. 12), maintains the temperature at the extreme value with an accuracy of 0.5%. This regulator is provided with an air reversing arrangement insuring high stability of control even in event of intensive disturbances.

The application of a reversing arrangement for increasing the stability of furnace performance was proposed by Prof. Kazakevitch in 1943. The use of such a reversing arrangement minimizes the variations in the air feed, which has a positive influence on the stability of the system. The nature of the action exerted by the reversing arrangement on the system is illustrated by the curve in Fig. 11.

Optimum Parameter Control

Extreme parameter regulators are self-adjusting systems of simplest form in which elementary means of computing technique are used. Systems of reflection control based on optimum parameters are of a superior design. This class of systems includes the so-called self-adjusting systems that can (1) automatically modify process conditions according to a pre-determined or random law, (2) evaluate the results of manufacturing units, as well as (3) store and select most efficient operational routines on the base of acquired experience. The main component of such systems is the control computer. At present, the theory and practice of designing such computer devices are only in the first stage of development. However, they are expected to have a great role in the future.

Conclusion

In conclusion it must be noted that computer devices for manufacturing process control and operations research are far from having reached full completion, and they have not yet found wide application in various fields of the national economy.

In the near future we are sure to observe progress and wider application of computer devices. Not only will large-scale and complex computers be used for the control of whole factories and systems, but also small-scale computers are to find wide application almost everywhere. These computers, in the form of small "mathematical units," such as extreme logic regulators or functional units, may find application everywhere, being of great aid in preparing the ground for the future application of complex computers in automatic control systems.

A point of great importance in the development of computer devices for process control is to secure reliable performance during a long period of service in the conditions of the given manufacturing plant. A great deal of work is yet to be done in this connection. Semiconductors, magnetic and thyrite elements, microwire resistors, and other new items and materials promise increased reliability.

We may hope that, during the decade to come, logic and computations will find their way into the general practice of systems for the automatic control of manufacturing processes and plants in all branches of modern technique.

Announcement on the International Yard and Pound

DIRECTORS of the following standards laboratories:

Applied Physics Division, National Research Council, Ottawa (Canada)
Dominion Physical Laboratory, Lower Hutt (New Zealand)
National Burea of Standards, Washington (United States of America)
National Physical Laboratory, Teddington (United Kingdom)
National Physical Research Laboratory, Pretoria (South Africa)
National Standards Laboratory, Sydney (Australia)

have discussed the existing differences between the values assigned to the yard and to the pound in different countries. To secure identical values for each of these units in precise measurements for science and technology, it has been agreed to adopt an international yard and an international pound having the following definition:

the international yard equals 0.9144 metre;
the international pound equals 0.453 592 37 kilogramme.

It has also been agreed that, unless otherwise required, all nonmetric calibrations carried out by the above laboratories for science and technology on and after July 1, 1959, will be made in terms of the international units as defined above or their multiples or submultiples.

The international inch, derived from the international yard, is exactly equal to 25.4 millimeters. This value for the inch has been legally adopted by Canada. Also this value was approved by the American Standards Association for "Inch-millimeter conversion for industrial use" in 1933 (ASA Standard B48, 1-1933), was adopted by the National Advisory Committee for Aeronautics in 1952, and has been adopted by many standardizing organizations in other countries.

At present for the calibration of line standards and end gages having nominal lengths expressed in inches, the National Bureau of Standards is using the inch defined by the Mendenhall order (Fundamental Standards of Length and Mass, Bulletin No. 26, United States Coast and Geodetic Survey by T. C. Mendenhall) published in 1893. The values corresponding to this order are approximately

1 yard = 0.91440183 meter;
1 inch = 25.4000508 millimeters.

These are derived from the exact relation

1 yard = 3600/3937 meter.

The inch used by the National Physical Laboratory of the United Kingdom for its calibrations is defined by the equation 1 inch = 25.399956 mm.

Note that the International Inch is approximately 2 parts per million shorter than the inch presently used by the National Bureau of Standards, and somewhat less than 2 parts per million longer than the inch now used by the National Physical Laboratory. To avoid possible confusion, during the transition period National Bureau of Standards calibrations of length or mass expressed in English units will embody a statement indicating clearly the unit which has been used if the choice introduces a significant difference in the calibration values.

The Coast and Geodetic Survey has requested the following exception with which the National Bureau of Standards concurs.

> "Any data expressed in feet, derived from and published as a result of geodetic surveys, shall tacitly bear the relationship:
>
> $$\text{One foot equals } \frac{1200}{3937} \text{ international meter.}$$
>
> This relationship shall continue in being, for the purpose given herein, until such a time as it becomes desirable and expedient to readjust the basic geodetic survey networks in the United States, after which the ratio, as implied by the international yard, shall apply."

This unit shall be referred to as the American Survey Foot.

The values of the pounds currently in use in the United States, United Kingdom and Canada are as follows:

1 U. S. pound =	0.453 592 4277	kg
1 British pound =	0.453 592 338	kg
1 Canadian pound =	0.453 592 43	kg
1 International pound =	0.453 592 37	kg

The relative differences in the various pounds are substantially less than in the yards but since masses can be measured with greater accuracy than lengths, the differences can be significant. The present British pound is about one part in ten million smaller than the international pound, whereas the U. S. and Canadian pounds are about one and one-half parts in ten million larger.

The conversion factor for the international pound was selected so as to be exactly divisible by 7 to give the following value for the grain:

1 International grain = .06479891 gram

The grain is the common unit in avoirdupois, apothecary and troy pounds. There are 7000 grains in the avoirdupois pound, and 5760 grains in both the apothecary pound and the troy pound.

The standard U. S. gallon and the Imperial gallon are so substantially different that a compromise international gallon was not practicable. The U. S. gallon is defined as equal to 231 cubic inches. On the other hand the Imperial gallon is defined as the volume of 10 pounds of water under specified standard conditions. A fairly exact relationship is

1 Imperial gallon = 1.20094 U. S. gallons,

or less exactly

1 Imperial gallon = 6/5 U. S. gallons.

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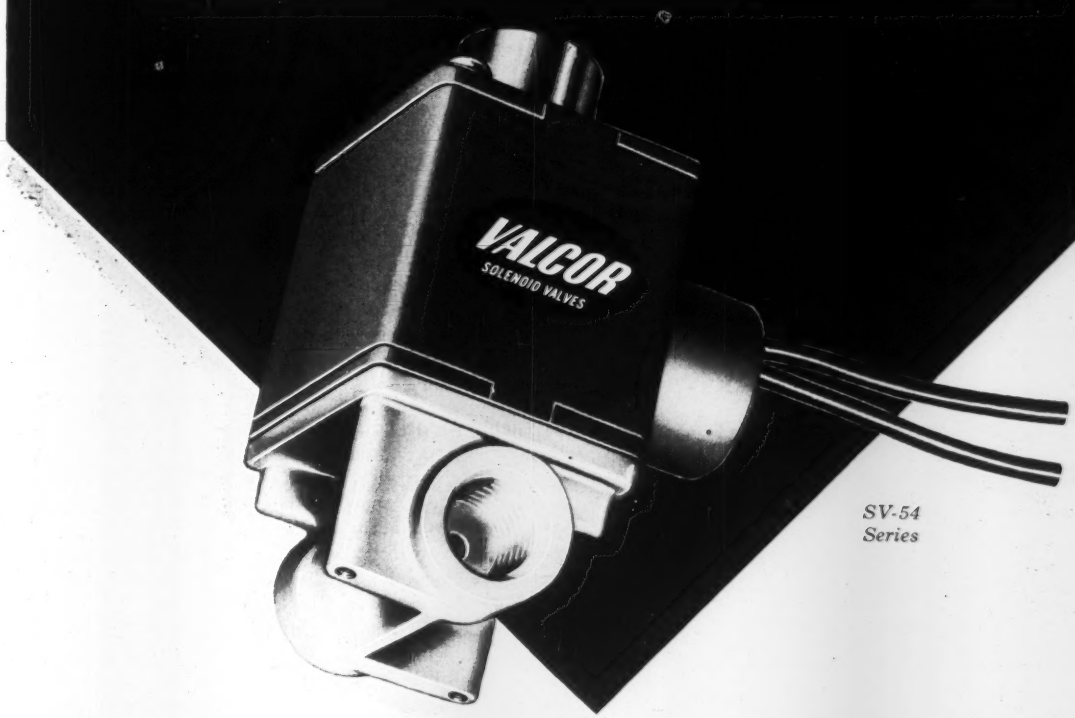

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Its nylon seat outlasts steel... its port threads outlast steel . . . pound for pound it's *3 times stronger than steel.* Dry seal threads, no compound is needed— and they won't loosen even under severe vibration. Nylon is non-corrosive so you have no atmospheric problems. And the stainless plunger is a reliable workhorse for millions of cycles. Bubble tight sealing. Available in normally open, normally closed and "directional control" configurations in all normal AC and DC voltages...1¼" square x 3" long (valve illustrated).

Write today for complete technical data on this shock-resistant, pressure-proof valve— the 3-way nylon-body valve, SV-54 Series, that's 3 times stronger than steel, yet costs less. Try it on your toughest application.

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Journal of the S C M A . . .

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FIELD TEST UNIT for DYNAMIC ANALYSES

This mobile field test unit measures dynamic response characteristics of plant units and control equipment. The truck is the control center for introducing known disturbances and recording the resulting system reactions at the test site.

A. BREMER
Shell Development Company

MEASUREMENT of dynamic response characteristics of plant units and their associated control equipment has become increasingly important. Data obtained from these tests has resulted in more efficient plant operation and has made possible analog computer studies of common but difficult control problems.

The normal procedure for obtaining dynamic response characteristics is to introduce a known disturbance to a system, usually by changing the signal to a control valve, and recording the reaction of the system at various other points. A descriptive equation or transfer function which adequately describes the system can be derived from the amplitudes and time lags of these reactions.

The first field test of this type by Shell Development Company was made at the Houston Refinery in 1951, and the following year two other tests were made. The first recording system, which is still being used, was a 4-channel system which provided data on three important process variables plus the input signal.

As more and more information was obtained on processes, equipment and control systems, it became obvious that more variables should be recorded concurrently. The additional equipment needed for 12 or 14 channels ruled out the station wagon as a means of transportation. Now signal generating equipment and a 14-channel recording system are installed in an air-conditioned, sound-proof truck, which is the control center for field tests of this type.

February Meeting: Thursday 19th, Rio Hondo Country Club, Downey, California
Technical Program: "Graph Alarm System" by Mr. Nels Swanson

Description of Truck

A tentative design made for the body was based on the dimensions of the chassis, approximately 7′ wide and 9′ long. An arbitrary inside height of 6′ 2″ was selected. General specifications for the body included aluminum material for the frame and shell, 2″ of fiberglass insulation in walls and ceiling, plywood interior walls, acoustical ceiling, linoleum-type floor, two side windows and a window in the rear door.

With the body completed the interior dimensions are as follows: length 9′ 3″ at the floor and 8′ 6″ at the ceiling; width is 7′; height is 6′ 2″. The weight of the truck and body as received from the manufacturer was 5700 pounds.

Permanent Fixtures

The rear 5′ of the body is used for storage compartments and work benches (Fig. 2). Along each side is a 3′ high work bench with Formica top extending 26″ from the wall. The area under the benches is divided into 4 base cabinets with sliding doors, 1 cabinet with a hinged door and 6 drawers.

Electric System

The electric power for the truck is usually supplied at the test site from a 440-volt, 60-cycle circuit, although 110 volts also can be used. The main connection is made at the outside of the truck to an explosion-proof fitting. From this connection the wires are tied through a constant-voltage regulator to a distribution panel in the truck which contains one 15-ampere and three 20-ampere breakers. Supply voltage to the signal generator and the recording equipment must be con-

stant so that variations in main line voltage will not introduce errors during a test. One of the four circuits is for the interior lights, one is for the air conditioner and two are for the wall plugs.

The interior lighting consists of six 20-watt fluorescent lights along the ceiling just in front of the wall cabinets, and four 20-watt units along the side walls just above the benches. All of the lights are controlled by a single switch at the rear door.

Electric outlets are located on the front and both side walls of the body. There are six 2-wire outlets and twelve 3-wire Twist-Lock outlets to accommodate the recording equipment, test apparatus and electrical tools.

Air Conditioning

A ¾-hp air conditioning unit is provided for heating and cooling the body. This unit is mounted on the front wall with the outlet close to the ceiling. It operates as a reverse-cycle heat pump with a cooling capacity of 8500 BTU/hr and a heating capacity of 9000 BTU/hr.

Power Panel

The main panel for both air and electric power is shown in Fig. 3 below the reel compartment. In addition to the main electric inlet mentioned previously, a locking air hose connector is provided for 50 psig instrument air. These two main power inlets are located at the left side of the panel. Eight ¼" Snap-Tite air couplings are also located on the panel for transmitting and receiving pneumatic signals between the test panel in the truck and the system being tested.

The other item on the panel is a terminal strip which is connected to a 16-point Brown recording potentiometer inside the truck. Up to 16 thermocouples can be connected to this strip for monitoring process temperatures.

Recording Equipment

Measuring Elements. Three basic types of measuring elements are used with the recording instruments to obtain process reactions to input disturbances. These include pressure and differential pressure transducers, resistance thermometers and differential transformers. Typical pickups of each type are shown in Fig. 4. In addition to these basic elements, vibration, acceleration and torsion pickups can be used when necessary.

The pressure and differential pressure transducers are Statham gages of various ranges. The most commonly used pressure range is 0-20 psig, although ranges of 30, 50, 100, 500 and 1000 psig also are on hand. The pressure to be measured is introduced into a small bellows to cause a displacement that is proportional to pressure. This displacement is then converted into a proportional resistance change. The bridge resistance is normally 350 ohms, but some of the older units have values of 500 or 675 ohms.

Differential-pressures ranges are 2, 4, 5, or 10 psi differential. A second method uses standard pneumatic differential pressure transmitters of the force-balance type with 20-psi transducers on the output.

Resistance Thermometers. The temperature pickups

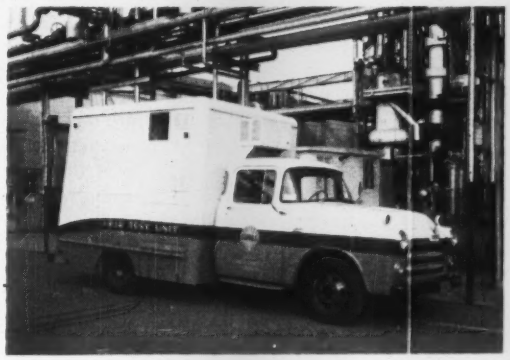
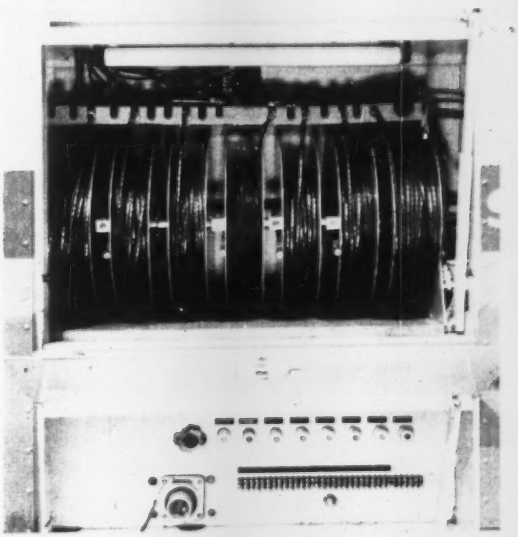


FIG. 1. FIELD test truck.

FIG. 2. INTERIOR VIEW of field test truck looking forward from rear door.

FIG. 3. MAIN POWER PANEL for field test truck. Electric-signal reels are at top; air-signal jacks are at top of lower compartment, which also has main power connector and thermocouple terminals.



are tip-sensitive Foxboro Dynatherm resistance elements arranged in special bridge networks designed and built at Shell Development Company. The Foxboro element with its padder resistors constitute one half of the bridge, and two fixed resistors with a variable potentiometer make up the other half. With this combination, the unit has a fixed 100°F span which is continuously adjustable within the range of −50 and +600°F. Measured temperatures can be read with an accuracy of ±2°F by balancing the Sanborn amplifier and reading the zero suppression dial directly as percent of the 100°F span that is being used. The bridge circuit has the advantages of being simple to use and accurate; they are interchangeable with each other and require no modification of the recording equipment. Maximum sensitivity of the pickups is about 1°F full scale.

Motion Transducers. The motion or displacement transducers are Schaevitz Linear Variable Differential Transformers with ranges of ±0.005″ to ±1.0″. These basic units have been mounted in non-conductive housings which can be installed in any position. Exact alignment of the core and the coil is not necessary.

Connecting Cables and Reels

The connecting cables between the various pickups and the recording system consist of two pairs of shielded wires in one plastic sheath about 0.030″ thick. They are in lengths of 300′ and 500′, and are wound on reels in two compartments of the truck (see Fig. 3). Seven reels are located on each side of the truck, 2 with 500′, 4 with 300′ and 1 with 500′ of telephone cable. Each reel has a spring-loaded rod mounted on one side which can be locked into a keyway on the reel shaft. An air motor and gear reducer drive this shaft with sufficient speed and torque to rewind 500′ of cable in a couple of minutes. The motor can be stalled to untangle the cable if necessary.

The connecting plugs are all Cannon Type WK. At the transducer end the connectors are 4-prong, and at the recording end they are 5-prong. Short cables running between the recording system and the reels are permanently mounted in the truck, but so arranged that any amplifier can be connected to any of the reels. Two portable reels, each holding 300′ of cable, are carried in case all 14 channels of the recording system are used.

Recorder

A 6-channel Sanborn Recording Oscillograph records the measured signals. This unit will record frequencies up to 100 cps on heat-sensitive paper with rectangular coordinates. The chart speed is adjustable in 9 steps between 0.25 and 100 mm/second, and a 1-second timing marker provides an indication of the chart speed being used. Each writing arm, or stylus, has an individual temperature control for varying the width of the chart line.

The recorder is housed in a metal cabinet 19″ x 21″ x 22½″, and is mounted semi-permanently on the floor of the truck against the front wall. Associated amplifiers and triplexers are mounted above it (see Fig. 2).

Strain-Gage Amplifiers. The Sanborn strain-gage amplifiers are designed to couple a bridge network to a Sanborn recorder for indicating bridge unbalance. They are of the conventional modulated-carrier type in which the bridge is excited at 2500 cycles by a built-in oscillator which provides 3 volts of excitation voltage. The bridge unbalance is amplified at 2500 cycles, rectified by a phase-sensitive detector circuit, and the resulting dc is applied to a driver amplifier which has sufficient output to operate the recorder.

Uncalibrated control knobs are provided for adjusting the resistive and capacitive balance of the bridge, the gain, and the zero position of the recording stylus. Calibrated knobs are provided for the gage-factor setting, zero suppression and step-wise attenuation. The zero can be suppressed up to 100% of transducer rated load. Six of these units are installed in the truck and are connected directly to the six channels of the recorder.

D-c Amplifiers. Two standard Sanborn d-c amplifiers will be mounted in the truck when needed, but their use will be rather limited. This amplifier comprises three direct-coupled push-pull stages.

Six steps of attenuation allow sensitivities of 50 mv to 50 volts for 1-cm deflection. The maximum allowable input voltage is 250 volts. This sensitivity is insufficient for measuring thermocouple voltages without the use of a preamplifier.

Carrier Triplexers

The Sanborn Carrier Triplexers are special units designed to Shell Development specifications. They are used to sample the output of 1, 2, or 3 external transducers in rapid succession, so the data can be recorded with respect to three separate base lines on one channel. Four of these Triplexers are mounted in the truck just above the recorder. With the 6-channel recorder it is possible to record up to 14 variables by triplexing 4 channels and recording single variables on the other 2.

The Triplexer consists of the following components: (1) A regulated power supply, (2) a power amplifier which is excited by the carrier voltage of the strain-gage amplifier to which it is connected, (3) an electronic switch which selects any combination of the transducers for recording, (4) three separate bridge input circuits.

Each of the bridge circuits, which is nearly identical to the strain-gage amplifier circuit, is fed to a cathode follower. The plate supply voltage for each cathode follower is derived from a multivibrator. The three multivibrators are connected in cascade so that each one is triggered in sequence. The "on" time for each multivibrator, and therefore the sampling time for the corresponding input signal, is individually adjustable from 0.067 to 0.20 second.

In using the recording system, each Triplexer is connected through a strain-gage amplifier to one channel of the recorder. A circuit diagram for 14-channel recording is shown in Fig. 6. A section of an actual record with 12 signals on 4 recorder channels is shown in Fig. 7. The signals can be identified by a difference in dwell time. In actual practice a better means of identification may be found in the high-frequency components of the measured signals; for example, flow records much different than temperature or pressure

records, and pressure usually can be distinguished from temperature.

Digital Equipment

All the data recorded on the Oscillograph also can be recorded digitally on punched paper tape. An Epsco Datrac Model B-102 analog-to-digital converter is time-shared among 20 analog channels. Of these 20 channels, 14 consist of data channels recorded on the Sanborn Oscillograph, 4 are available for recording reference signals from the sine-cosine wave generator and 2 are spares available for recording the outputs of analytical instruments.

The digital data is assembled into computer words and recorded on punched paper tape. Each computer word contains 4 time digits from a digital clock, and 6 data digits (3 from each of 2 data channels). Ten computer words contain the digital data from the 20 channels.

Punched paper tape is assembled in reels of 3000 words for data reduction on an ElectroData 205 Computer. The process of data reduction is essentially a digital version of the analog data reduction described in a recent publication.*

Sine Wave Generator

A synchronous motor drives a pair of sine-cosine potentiometers on a multiratio gear box having a range of speed of 24,000:1. The potentiometers are coupled electronically to a pair of Swartwout power relays to produce sinusoidal pneumatic signals. The two pneumatic outputs can be: (a) two separate outputs at different frequencies, or (b) two separate outputs at the same frequency, or (c) one output at two frequencies simultaneously, plus one output at one frequency.

The frequency range is from 1 cycle per 7 hours to 100 cycles per minute. The pressure level is adjustable from direct-reading potentiometers in the range of 3—15 psi, and the amplitude of the sinusoidal waves is similarly adjustable from zero to 6 psig. The two frequencies may be mixed with amplitude ratios of ¼, ½, 1, 2, or 4.

The reference signals, which are digitized, consist of the sine and cosine of each of the two frequencies which are generated.

Communication System

During a field test it is important to have good communication between the plant operators and the test crew. Four telephone headsets are provided for use outside of the truck. These units are powered from the truck and are connected by two 500′ cables with an outlet at the end of each 100′ from the end. A microphone and loud speaker are used inside the truck. All of this equipment is interconnected with each of the receivers and transmitters and left open, except the microphone in the truck. When the microphone is turned on, the speaker is turned off to prevent audio feedback.

*P.E.A. Cowley, The Application of an Analog Computer to the Measurement of Process Dynamics, *Trans. ASME*, Vol. 79, No. 4, May, 1957, pp 823-832.

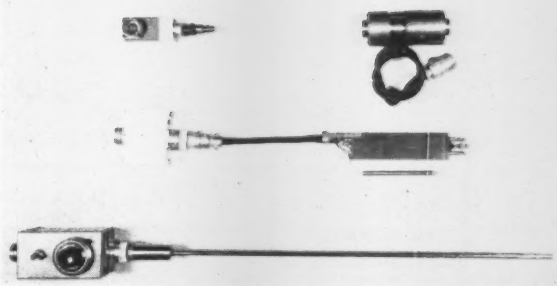


FIG. 4. BASIC MEASURING ELEMENTS. Top left is pressure transducer; top right is differential pressure transducer; center is Schaevitz differential transformer; bottom is resistance thermometer.

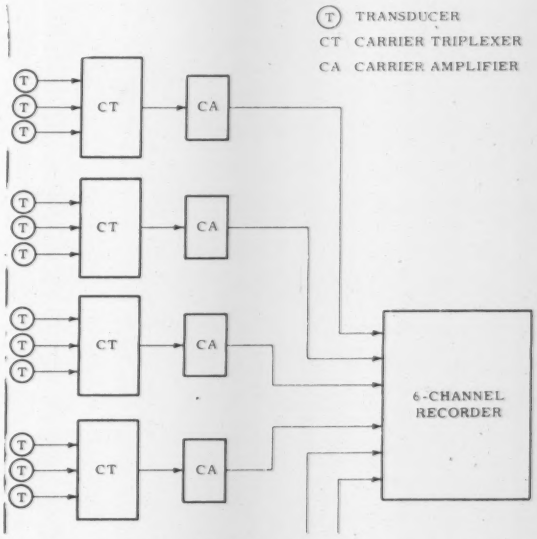


FIG. 5. WIRING DIAGRAM for 14-point recording.

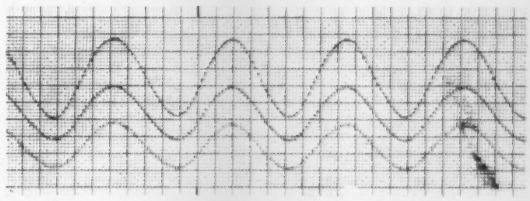


FIG. 6. SECTION of Sanborn chart showing triplexed records.

Conclusion

The field test unit has been in use since the latter part of 1955 gathering data on a variety of processing units, such as distillation columns, reboilers, preheaters and flow systems. As a result of these investigations we have obtained a better insight into equipment performance, and consequently have been able to improve performance in several cases.

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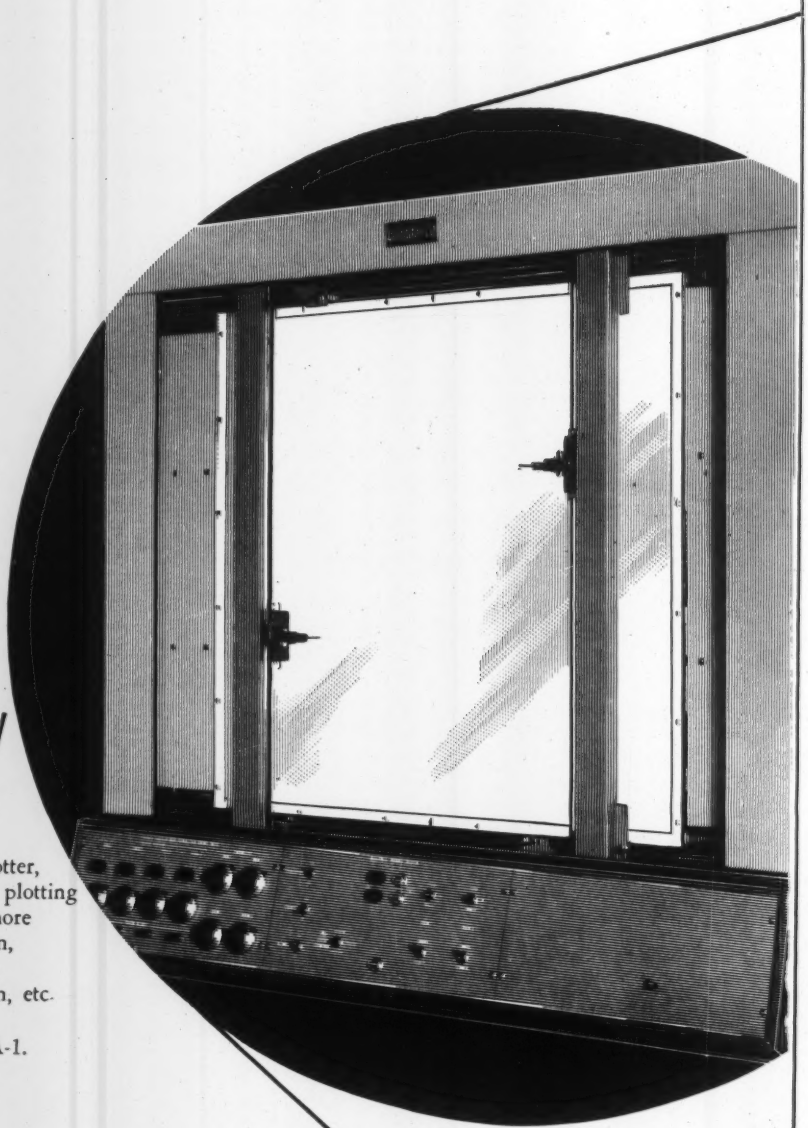

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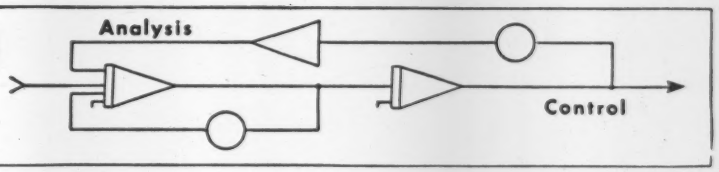

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Bits

This month we report part of the November meeting of the Western Simulation Council held at the University of California, Los Angeles, on "Simulation of Field Problems." Next month we'll finish the job.

In the past your Ed. has occasionally "edited" (i.e., loused up) reports of speakers' presentations when he believed (just possibly erroneously) that he knew what the speakers were trying to say. But this month I must refrain—I have no feel for the "Field" part of the subject, though the "Problem" presents no problem.

Pieces

WESTERN S/C MEETING OF NOVEMBER 20 ON "SIMULATION OF FIELD PROBLEMS"

The forty-one representatives of 19 organizations who signed the register at the November 20th meeting of the Western Simulation Council constituted only about two-thirds of those who gathered at UCLA to hear about "Simulation of Field Problems" and visit the Western Data Processing Center.

Irwin Pfeffer (Space Technology Laboratories, Los Angeles, Calif.) presided as chairman and introduced *L. D. Kovach* (Douglas Aircraft, El Segundo, Calif.), who described a method he has used for the simulation of field problems.

"I have every right," Dr. Kovach said, "to speak on the solution of partial differential equations; I've been getting partial solutions to ordinary differential equations for years!"

In a somewhat more serious vein Dr. Kovach said he was glad to be able to speak on the analog solution of partial differential equations because this is one area in which the analog people can stand toe-to-toe with the digital people and slug it out—nobody has a really good method for their solution, and in many respects the analog people have the advantage.

The partial differential equations of mathematical physics often fall into the form:

$$A\frac{\partial^2\phi}{\partial x^2} + 2H\frac{\partial^2\phi}{\partial x\partial y} + B\frac{\partial^2\phi}{\partial y^2} = I$$

in which A, B, H, and I may be constant (including zero), or functions of $(x, y, \frac{\partial\phi}{\partial x}, \frac{\partial\phi}{\partial y})$.

If $H^2 - AB > 0$, the equation is said to be *hyperbolic*. If $H^2 - AB = 0$, the equation is said to be *parabolic*. If $H^2 - AB < 0$, the equation is said to be *elliptic*. These terms are borrowed from the analogous quadratic forms, and are related to convenient subdivisions into which the solutions naturally fall.

Laplace's equation, $\nabla^2\phi = 0$, is satisfied by the velocity potential in an ideal incompressible fluid without vorticity, by gravitational potential in free space, electrostatic potential in the steady flow of electric currents in solid conductors, and by the steady-state temperature distribution in solids.

Poisson's equation, $\nabla^2\phi = K$, is satisfied by the velocity potential of an incompressible, irrotational, ideal fluid with continuously distributed sources or sinks, by steady-state tem-

perature distributions due to distributed heat sources, and by a 'stress function' involved in the elastic torsion of prismatic bars.

The *wave* equation $\nabla^2\phi = 1/c^2\ \phi_{tt}$, arises in the study of propagation of waves with velocity c, independent of the wave length. In particular, it is satisfied by the components of the electric or magnetic vector in electromagnetic theory, by suitably chosen components of displacements in the theory of elastic vibrations, and by the velocity potential in the theory of sound (acoustics) for a perfect gas.

The equation of *heat conduction*, $\nabla^2\phi = 1/a^2\ \phi_t$ is satisfied by the temperature at a point of a homogeneous body and by the concentration of a diffused substance in the theory of diffusion.

The bi-Laplacian equation, $\nabla^4\phi = 0$, is involved in many two-dimensional problems in the theory of elasticity.

Although the method of *separation of variables* (Fig. 1) is restricted in a mathematical sense to a comparatively narrow range of differential equations, fortunately this range includes a very large number of those equations which arise in practice.

$$\frac{\partial^2 u}{\partial y^2} = (1 - y^2)\ \frac{\partial u}{\partial x}$$

WITH $u = 0$ at $y = \pm 1$
$u = u(y)$ at $x = 0$

BECOMES $\frac{d^2 G}{d y^2} + \lambda^2 (1 - y^2)\, G = 0$

WITH $G(\pm 1) = 0$

FIG. 1. SEPARATION OF variables. The partial differential equation arising from the study of viscous compressible flow in a channel.

IF IN LAPLACE'S EQUATION

$$\frac{\partial^2 T}{\partial x^2} + \frac{\partial^2 T}{\partial y^2} = 0$$

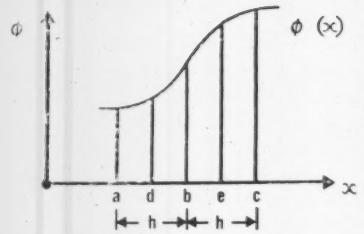
WE PUT

$$T = X(x)\,Y(y)$$

WE GET THE SYSTEM

$$\begin{cases} \frac{d^2 X}{d x^2} + \lambda^2 X = 0 \\ \frac{d^2 Y}{d y^2} - \lambda^2 Y = 0 \end{cases}$$

FIG. 2. SEPARATION of variables to get ordinary differential equations.



$$\left(\frac{d\phi}{dx}\right)_e \doteq \frac{\phi_c - \phi_b}{h}$$

$$\left(\frac{d\phi}{dx}\right)_d \doteq \frac{\phi_b - \phi_a}{h}$$

$$\left(\frac{d^2\phi}{dx^2}\right)_b \doteq \frac{\left(\frac{d\phi}{dx}\right)_e - \left(\frac{d\phi}{dx}\right)_d}{h}$$

$$\left(\frac{d^2\phi}{dx^2}\right)_b \doteq \frac{\phi_c + \phi_a - 2\phi_b}{h^2}$$

FIG. 3. FINITE differences.

In solving $\nabla^2 T = 0$, we look for product solutions of the form $T = X(x)\,Y(y)$, where X is a function of x alone and Y is a function of y alone. This leads to a system of ordinary differential equations which can then be solved in the usual manner (Fig. 2).

The characteristic strip method can be illustrated by considering the first-order partial differential equation:

$$f(x, y, z, \frac{\partial z}{\partial x}, \frac{\partial z}{\partial y}) = 0$$

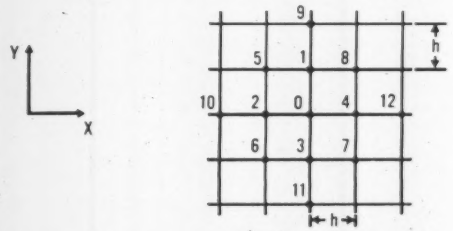
If we put $\frac{\partial z}{\partial x} = p$, and $\frac{\partial z}{\partial y} = q$, then the characteristic strips of our equation must satisfy the five ordinary differential equations:

$$\begin{cases} \dot{x} = \frac{\partial f}{\partial p} \\ \dot{y} = \frac{\partial f}{\partial q} \\ \dot{z} = p\frac{\partial f}{\partial p} + q\frac{\partial f}{\partial q} \\ \dot{p} = -\frac{\partial f}{\partial x} - p\frac{\partial f}{\partial z} \\ \dot{q} = -\frac{\partial f}{\partial y} - q\frac{\partial f}{\partial z} \end{cases}$$

which can be solved on a differential analyzer. The integral surface which represents the solution is built up from characteristic strips.

Undoubtedly the most versatile method of solving partial differential equations is to convert them to systems of *finite difference* equations. In order to give some mathematical background, consider first the conversion of ordinary differential equations to finite differences. Fig. 3 shows a function $\phi(x)$ and the approximations to the derivatives. It is apparent that the errors in these approximations are a function of the spacing, h.

If now the function depends on two variables, x and y, we cover the plane with a grid and write approximations to the partial derivatives (Fig. 4). Using these approximations our partial differential equation becomes a system of algebraic equa-



$$\left(\frac{\partial\phi}{\partial x}\right)_0 \doteq \frac{\phi_4 - \phi_2}{2h}$$

$$\left(\frac{\partial\phi}{\partial y}\right)_0 \doteq \frac{\phi_1 - \phi_3}{2h}$$

$$\left(\frac{\partial^2\phi}{\partial x^2} + \frac{\partial^2\phi}{\partial y^2}\right)_0 \doteq \frac{\phi_1 + \phi_2 + \phi_3 + \phi_4 - 4\phi_0}{h^2}$$

$$\left(\frac{\partial^4\phi}{\partial x^4} + 2\,\frac{\partial^4\phi}{\partial x^2 \partial y^2} + \frac{\partial^4\phi}{\partial y^4}\right)_0$$

$$\doteq \frac{1}{h^4}\left[20\,\phi_0 - 8\left(\phi_1 + \phi_2 + \phi_3 + \phi_4\right) + 2\left(\phi_5 + \phi_6 + \phi_7 + \phi_8\right) + \left(\phi_9 + \phi_{10} + \phi_{11} + \phi_{12}\right)\right]$$

FIG. 4. FINITE differences; approximations written on grid.

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How to Judge Electronic Multipliers—and Why

Now that non-linear operations have become more common in analog computation, components like multipliers are often the decisive determinants of over-all accuracy and computing speed. For this reason, and because published specifications are frequently incomplete and perhaps misleading, it has become worthwhile to take a particularly close look at multiplier performance. This situation was recognized as early as the Summer of 1957 when a committee of the Western Simulation Council took initial steps toward developing clear industry standards. Pending a report of this committee, we wish to point out a few questions which, when answered, help clarify performance.

Static Accuracy— It Seems Simple But...

Even static accuracy specifications can be ambiguous. In the case of four-quadrant multipliers it's not always clear whether stated accuracy applies to all four quadrants used simultaneously or only to one or two quadrants which the operator selects and adjusts for maximum accuracy. The best method of specification appears to be a three dimensional graph such as that in figure 1. This graph shows the error at any point in four quadrants used simultaneously. It may be supplemented by a statement of improved accuracy possible under one or two quadrant operation.

Wanted: Total Error vs Frequency Curves

Up to now no satisfactory equipment has been devised to measure the error developed when *both* inputs are varying as they do in a problem. However, a statement of dynamic error when one input varies sinusoidally while the other is held constant provides a fair estimate of actual performance.

Total dynamic error can be calculated from a Bode diagram of phase error and amplitude error plotted separately against frequency; but, because total error is a *vector* sum of these two errors, the procedure is tiresome. Much to be preferred is a graph of total error vs frequency such as that appearing in figure 2.

In interpreting either a Bode diagram or a "total error vs frequency" curve, one should know the amplitude of input signals. Ordinarily the greatest error will appear at maximum ac amplitude (usually 200v peak-to-peak) and maximum dc input (usually 100v dc).

What Happens Near Zero Output?

Because any error or noise near zero output becomes a large part of the total signal, it is wise to obtain figures on both static and dynamic error when one input is zero and the other is a maximum dc or ac signal. While the graph, shown in figure 1, provides ample information on static error, figure 2 should be supplemented by another set of curves to show dynamic error near zero.

Will It Operate in a Feedback Loop?

Problems often require that multipliers be connected in a feedback loop. The tendency to cause oscillation in the loop can be estimated by examining a Bode diagram of gain and phase shift plotted against frequency. From these curves you may learn how much phase shift and gain may exist in the remainder of the loop before oscillation will occur. Stable loop performance is facilitated by a multiplier with adequate gain and phase margins.

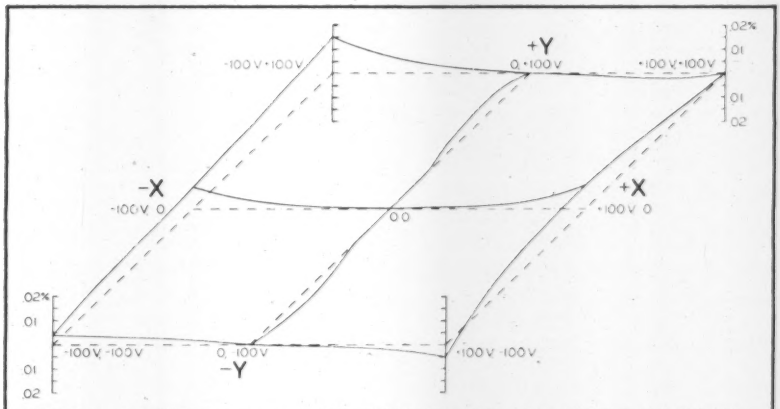

FIGURE 1. Plot of typical static error in EASE Model 1157 multiplier. Error is plotted on vertical scale against map of all combinations of X and Y values. Note low error near zero.

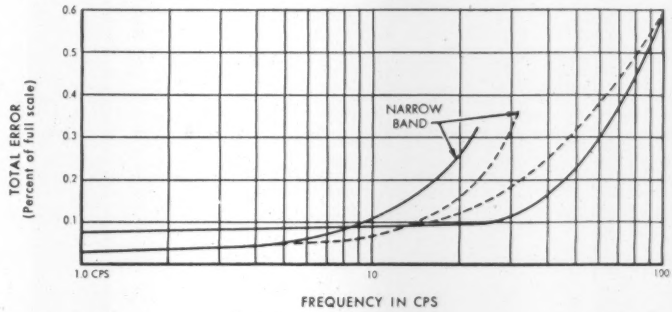

FIGURE 2. Typical plot of total error vs frequency for EASE Model 1157 multiplier-divider. (200v peak-to-peak at one input, ±100v dc at the other.) Curves show narrow band and wide band operation as well as multiplying performance (solid line) and dividing performance (dashed line).

A Few Additional Specs On the EASE 1157 Multiplier

Typical gain margin: 10 db below unity
Phase margin: Approx 90°
Dynamic error with X = 0, Y = 200v peak-to-peak:
less than 25mv up to 30cps

Detailed technical data on EASE electronic multipliers is available on request

C5

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For more information circle **74** on inquiry card.

tions which can be solved on a differential analyzer.

An example of the use of this method is shown by the heat conduction problem in one dimension (Fig. 5). While admittedly the differential analyzer solution (Fig. 6) requires a large number of amplifiers, the setup is fairly simple and the boundary conditions can be varied easily. Moreover, although the specific heat, C, and the thermal conductivity, K, are both functions of x, the circuit can handle these variables quite simply.

Wadel* has shown how a differen-

*Louis B. Wadel, "An Electronic Differential Analyzer as a Difference Analyzer," *Journal of the Association for Computing Machinery*, v. 1, No. 3, July 1954. A related paper is "Simulation of Digital Filters on an Electronic Analog Computer," *Journal of the Association for Computing Machinery*, v. 3, No. 1, January, 1956, also by Wadel.

$$c(x)\frac{\partial T(x,t)}{\partial t}=\frac{\partial}{\partial x}\left[K(x)\frac{\partial T(x,t)}{\partial t}\right]+f(x,t)$$

TRANSFORMS INTO

$$C_n\frac{dT_n}{dt}=\frac{K_{n+1/2}}{h^2}(T_{n+1}-T_n)-\frac{K_{n-1/2}}{h^2}(T_n-T_{n-1})+f_n$$

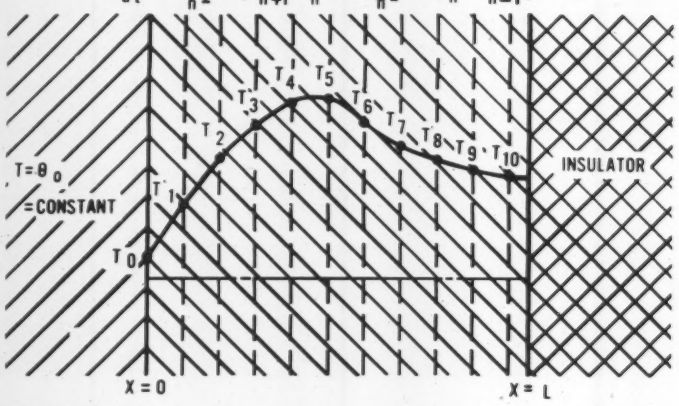


FIG. 5. FINITE differences; heat conduction problem, in one dimension.

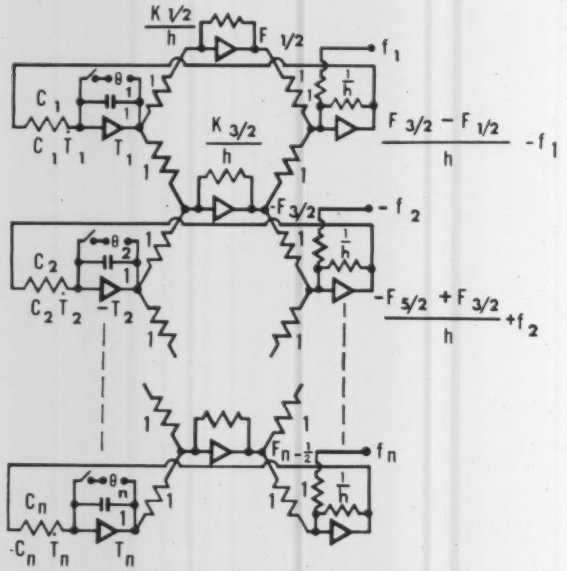
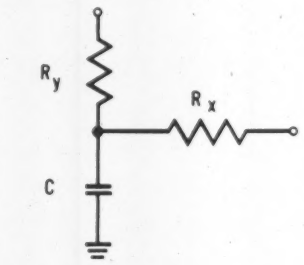


FIG. 6. FINITE differences; differential analyzer solution.

$$\frac{\partial^2\phi}{\partial x^2}+\frac{\partial^2\phi}{\partial y^2}=k\frac{\partial\phi}{\partial t}$$

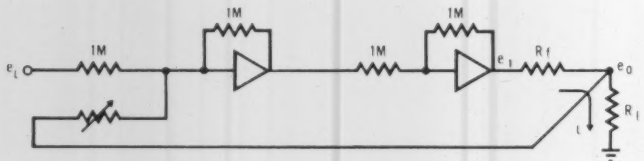


CAPACITANCE IS PROPORTIONAL TO k

R_y IS PROPORTIONAL TO MESH SIZE ALONG Y - AXIS

R_x IS PROPORTIONAL TO MESH SIZE ALONG X - AXIS

FIG. 7. PASSIVE elements; transient heat flow in two dimensions.



SINCE $e_1 = e_L + e_0$

AND $e_1 - e_0 = i_L R_f$

WE HAVE $e_L = i_L R_f$

OR $i = \frac{e_L}{R_f}$

FIG. 8. CURRENT generator with current output independent of the load resistance R_1.

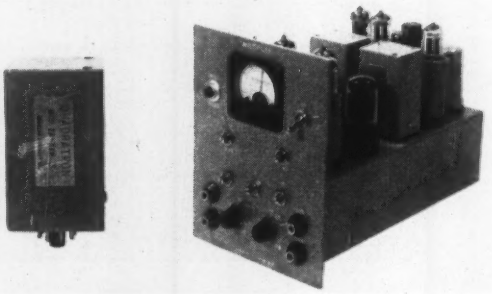


FIG. 9. THE QUADRATRON, from the latin "Quadrare" (to square) and "Tron" as in electron, and a quarter-square multiplier.

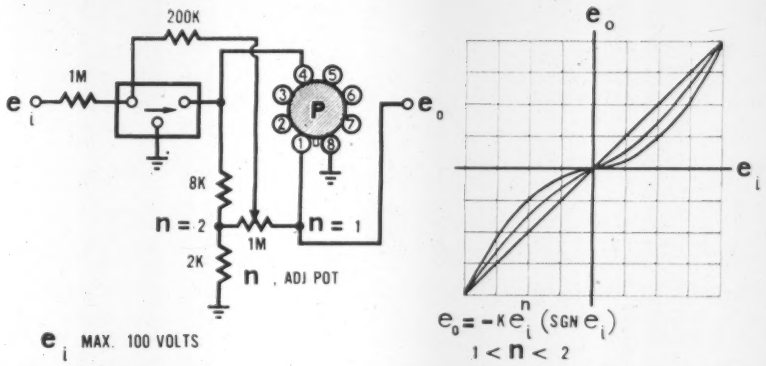


FIG. 10. SIMULATION OF radiation term with one amplifier, an application of the Quadratron.

tial analyzer can be converted into a *difference analyzer* for solving finite difference equations. In this method integrators are used as storage elements and it is necessary to have 'reset', 'operate' and 'hold' conditions. Each solution corresponds to a value at a node of the mesh.

A great saving of amplifiers can be achieved by using *passive elements* such as resistors and capacitors. If the region over which the solution is desired is covered with a net of resistors and capacitors, then only the varying boundary conditions require the use of amplifiers. In a circuit of this type temperature is simulated by voltage, and heat flow by current flow (Fig. 7). Boundaries can be kept at constant or arbitrary temperatures and current can be injected into the various nodes by using current generators which can be made from two amplifiers (Fig. 8).

While some of the methods discussed can be used when *nonlinearities* are present, the presence of products and various exponents presents new challenges to our ingenuity. In a recent problem involving heat transfer through a laminated windshield complete with defrosters and deicers our equipment was taxed to the utmost. We simulated this problem with the aid of passive elements and operational amplifiers. The latter made it possible to obtain the nonlinearities and the passive elements represented heat conduction through the laminated material.

This and other similar problems caused us to give some serious thought to the simplified representation of nonlinearities. The results of our work are contained in a device which we call a Quadratron. This is a passive device, fully temperature compensated, of good accuracy and having extremely wide application. Fig. 9 shows the Quadratron and a quarter-square multiplier which we built. In heat flow problems the simulation of radiation losses is sometimes quite difficult. Fig. 10 shows our simplified circuit for representing radiation terms. Although the Quadratron performs a squaring operation, appropriate circuitry can modify this behavior. Fig. 11 shows a system for obtaining any exponent between 1 and 2.

Since there are no general methods for solving partial differential equations, each problem must be examined individually. There is a need for simpler techniques and better methods

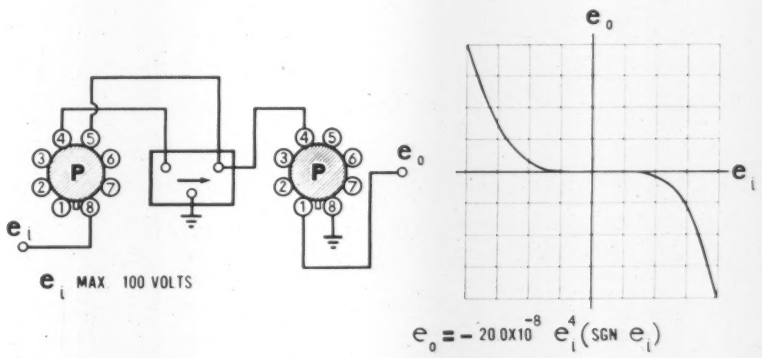


FIG. 11. SIMULATION OF an arbitrary exponent with one amplifier.

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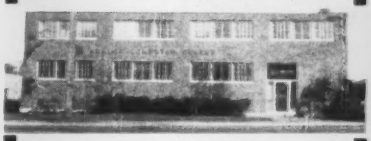

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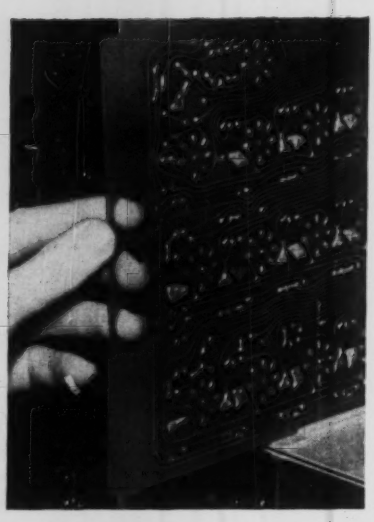

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in all phases of this subject. Finally, it should be mentioned that you analog computing engineers and simulation engineers are on even terms with with mathematicians and the digital computing engineers. The latter are also forced to separate the variables, use characteristic strips and reduce to finite difference equations.

Asked whether the Quadratron was commercially available. Dr. Kovach said not yet, but implied that he thought it would be through licensing of the patent.

Irwin Pfeffer asked about accuracy and was told 0.4% of range at present. They are shooting for 0.1%. The multiplier accuracy is nominally about 0.8%, but if you're clever you might get 0.4%.

Asked whether the nonlinear element was the thyrite, Dr. K. replied that it was.

Following these questions Irwin introduced the next speaker, *W. J. Karplus* (UCLA).

(Karplus' talk next month)

Information (Without Theory)

Something new has been added! Our friend and ex-colleague, *Dean Morehead*, who is now Veep of Space Data, Inc., dropped in with what to us was news:

1. Colorado Research Corporation has entered the general-purpose analog computer field.*

2. Space Data will represent CRC on the whole West Coast except for San Francisco area.

We are informed that outstanding features of the CRC Model 200 computer are:

Operator convenience, "unmatched in the field," resulting from user-oriented design philosophy.

Keyboard programming, which provides fingertip control of complete analog system.

Digital coefficient entry, permitting high-speed setting of four-place numerical values.

Automatic scan for readout or adjustment of computing elements—a built-in capability.

High precision, achieved by exclusive use of 0.01% passive components.

Low cost of the basic computer, making the Model 200 accessible to "the most modest budget."

* Dave Miller should have kept us better informed!

Unlimited expansion potential due to large patchboard capacity and the ability to easily slave additional consoles to form a large computational unit.

Ken Tuttle tells us that the Beckman/EASE people are planning a symposium on Management Problems in Organization and Operation of Computing Facilities, to be held at their Los Angeles Computation Center in mid-February. We understand that papers will be presented from both the analog and digital points of view, with emphasis on the administrative aspects of running a facility containing both kinds of equipment.

He Went–Too Soon

We were shocked and saddened to be informed by *J. H. Milsum* of the National Research Council in Ottawa of the untimely death of our friend, and benefactor of simulation, *Fred Pruden*.

Fred died suddenly on Saturday, 15 November, while en route from London to Ottawa after a vacation in Europe.

He was born in London in 1922 and came to Canada in 1947. However, we didn't meet him till the formation of the Canadian Simulation Council in November '56. Fred was instrumental in our being invited to Ottawa on that occasion and for our introduction to Canadian hospitality.

We cannot improve on the closing paragraph of the obituary which Mr. Milsum sent us:

"Fred's widespread knowledge of matters scientific and his ardent desire to extend this knowledge to further fields made him a continual inspiration and challenge to his colleagues. His loss at such an early age is deeply regretted by all his friends. It is, perhaps, some small consolation that his few years have been so filled with accomplishment."

Computer Events

High-Speed Computer Conference

Dates: 10-13 February 1959

Place: Louisiana State University

Eastern Simulation Council Meeting

Date: February 16, 1959

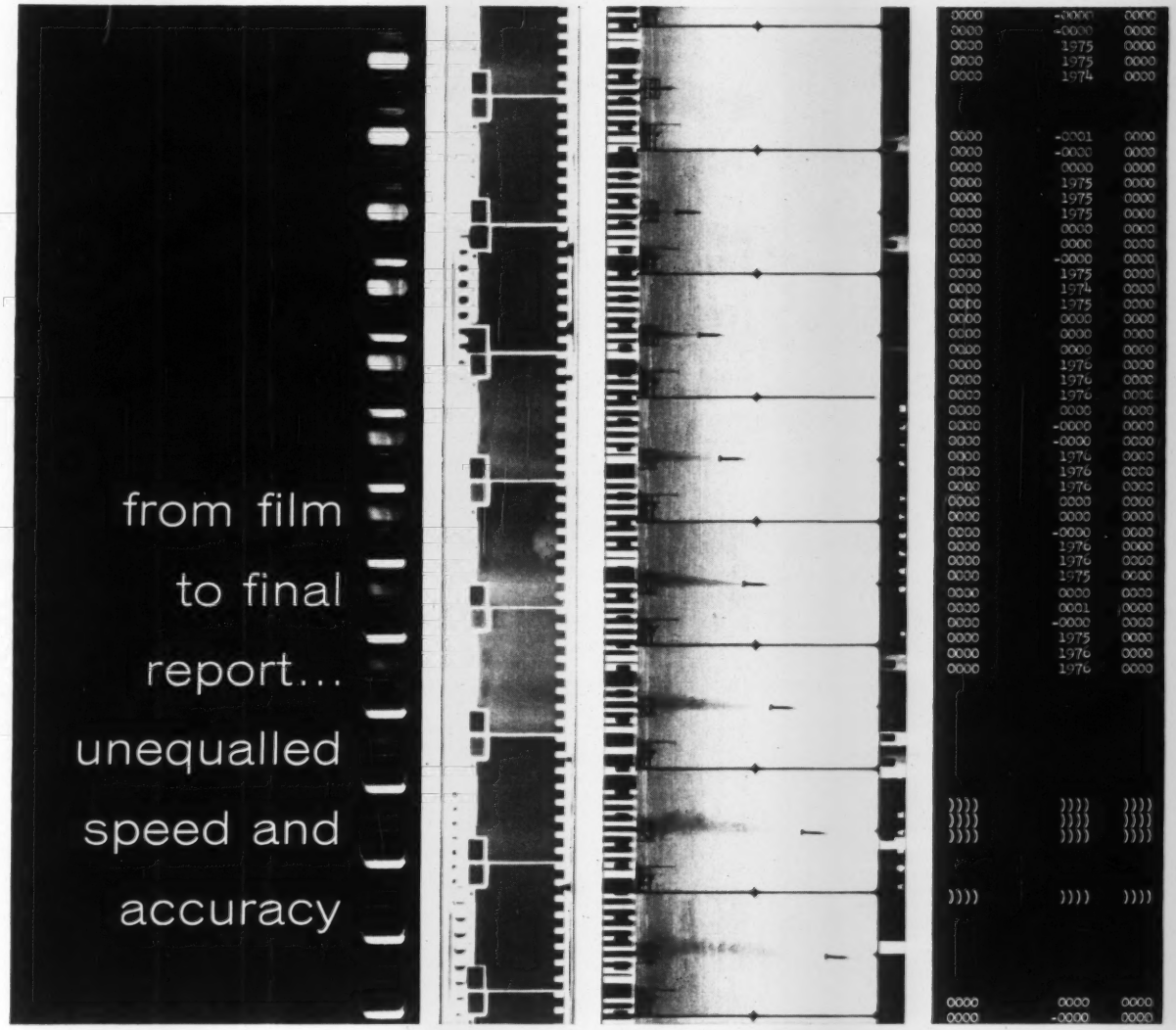
Place: Grumman Aircraft Eng. Corp. Bethpage, L. I., N. Y.

Topic: Men, Machines and Simulation

Western Joint Computer Conference

Dates: 3-5 March 1959

Place: San Francisco, Calif.



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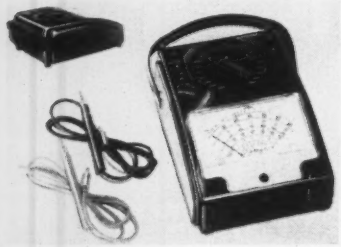
New all-electronic transistorized Model 81 Digital Voltmeter features accuracy and resolution of 0.015% over the three automatically-switched ranges of ±10, ±100, and ±1000 vdc.

Input impedance of the instrument is 10 megohms, output presentation is by both a dot-projected visual readout and a ten-line decimal code. Applications include production testing, precision research measurements, telemetry, and alarm monitoring.—*Beckman, Systems Div., 325 N. Muller Ave., Anaheim, Calif.*

For more information circle **180** on inquiry card.

POCKET-SIZE VOM

New low-cost portable 5" meter is battery operated and features improved physical design with inclined panel whereby it lies flat in normal



use position. Center scale ranges are: 5, 500, 5000, 500,000 ohms.—*Hickok Electrical Instrument Co., 10519 Dupont Ave., Cleveland 8, Ohio*

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TELEMETRY SYSTEMS

New miniaturized frequency-type system using transistors and magnetic devices, measures any process variable such as temperature, pressure, liquid level, flow, megawatts and the like, that can be converted into an electrical signal, and transmits them as frequencies over any kind of communications channel to a control center. Transducers are used

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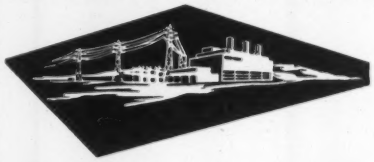
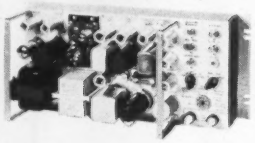
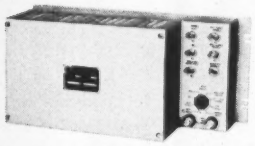




MODEL 1025 Transmitter

MODEL 1090 Receiver



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at sending and receiving ends. Accuracy is ±¾%; linearity is within ½%.

Another new system (Dur-O-Pulse) is a pulse-type system which also transmits process intelligence as electrical signals, but only at five- or 10-sec intervals instead of instantaneously. The time length of each pulse is the value of the process variable. No repeater relays are needed up to 100 miles from the source. System consists of a recorder or indicator at the point of measurement, a power pack for transmission of the signal, and a receiver in a second instrument at the receiving location.—*Brown Instruments Div., Minneapolis-Honeywell Regulator Co., Wayne & Windrim Aves., Phila. 44, Pa.*

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V-O-M ANALYZER

New Model 980 Mark II Analyzer, a highly sensitive volt-ohm-milliammeter, has a d-c sensitivity of 20,000 ohms/v, and an a-c sensitivity of

1,000 ohms/v. Accuracy is within 2% full scale d-c and 3% a-c. Fused ohmmeter circuits prevent burnout if voltages are mistakenly applied.—*Weston Instruments, Div. of Daystrom, Incorporated, Newark 12, N. J.*

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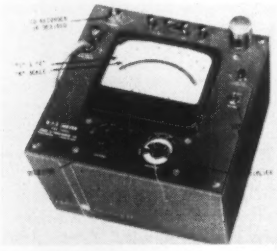
New R-I-E Meter, No. 5620, for drift-free measurements, allows resistance measurements from 2 to 2×10^8 megohms, with limits of error



between ±1.7% and ±6% of reading; current measurements of 1×10^{-12} to 5×10^{-6} amps, with limits of error between 1.5% and 3% of full scale; and voltage measurements of 0.005 to 500 v, with limits of error between ±0.5% and ±3% of full scale.—*Leeds & Northrup Co., 4934 Stenton Ave., Phila. 44, Pa.*

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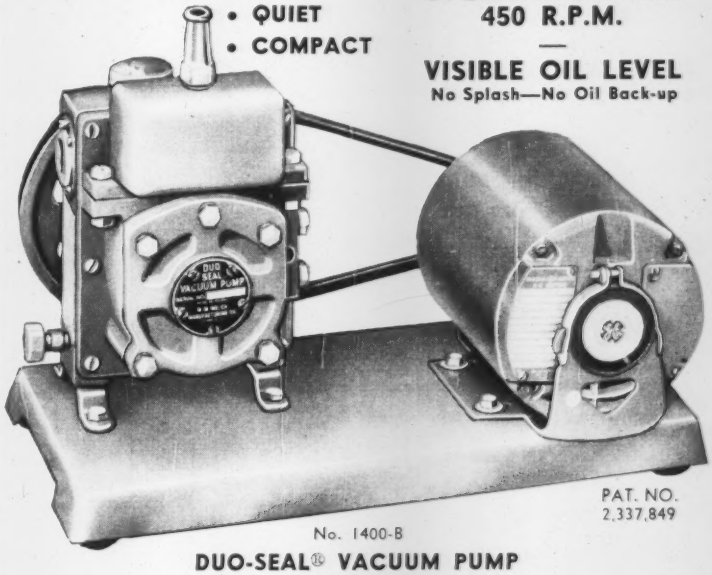

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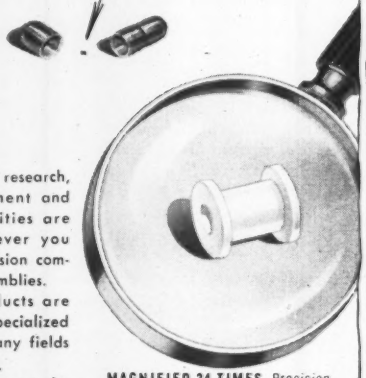

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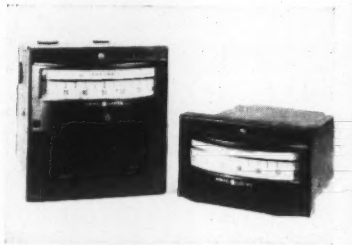
MVM CONTROLLERS

New HP-40 Resistance Thermometer featuring printed circuits, miniature components, and completely interchangeable plug-in units, has automatic continuous standardization



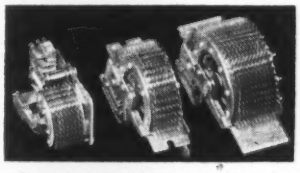
utilizing a silicon-diode reference voltage supply for the d-c measurement bridge.

★New Proportional-Position Controller, Type HP-37, for throttling control of valves, dampers, and rheostats has proportional band adjustable from 0.5% to 7%. Accuracy is within ± 0.5%. Component features are same as in HP-40.—*General Electric Co., Schenectady 5, N. Y.*

For more information circle **185** on inquiry card.

STEPPING SWITCHES

New spring-driven Stepping Switches with diallyl-phthalate insulation, which provides a minimum re-

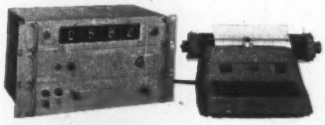


sistance of 100,000 megohms between switch points and between each point and the frame, meet MIL specifications.—*C. P. Clare & Co., 3101 Pratt Blvd., Chicago 45, Ill.*

For more information circle **186** on inquiry card.

DIGITAL VOLTMETER SYSTEM

New model DVV-412 four-digit AC-DC Voltmeter automatically measures a-c or d-c voltages and types the results on an electric typewriter. The system featuring totally transistor-



ized circuitry consists of an Universal Power Module, DC Switch Module, AC Converter Module, Typewriter Control Module, and an electric typewriter. A-c accuracy is better than 0.1% or two digits, over a 0.0001 to 999.9 range. D-c accuracy is better than ± 1 digit.—*Electro Instruments, Inc., 3540 Aero Court, San Diego 11, Calif.*

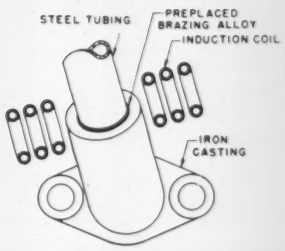
For more information circle **187** on inquiry card.

The Lepel Line of induction heating equipment represents the most advanced thought in the field of electronics as well as the most practical and efficient source of heat yet developed for industrial heating.

If you are interested in induction heating you are invited to send samples of the work with specifications. Our engineers will process and return the completed job with full data and recommendations without any cost or obligations.

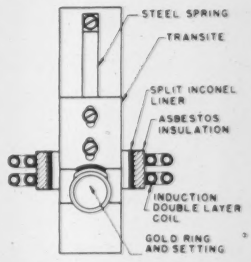
TYPICAL INDUCTION HEATING APPLICATIONS

IRON CASTINGS BRAZED TO STEEL TUBES



Assembly of iron castings and steel or copper parts are facilitated by induction heating. Arrangement is illustrated for silver brazing malleable iron castings to steel tubing. Coil design shown provides uniform heating for joint. Proper joint design assures high bond strength. Electrolytic treatment of castings to remove carbon (Kolene Treatment increases strength and tightness of joint to gases and liquids.

GOLD BRAZING IN JEWELRY INDUSTRY



Liner type induction coil shown provides a flexible arrangement for brazing settings to gold rings. The simple fixture facilitates handling. The unique coil design permits heating by induction and by radiation from heated metal liner. Ring, setting and gold brazing alloy are pre-assembled in a ceramic jig and then moved into heating position within the coil for brazing.

CUTTER BLADES SELECTIVELY HARDENED

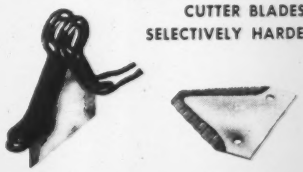


Photo shows coil design and arrangement used to selectively harden edges of cutter blades used in agricultural equipment. In production, cutter blades are automatically fed between layers of the induction coil, selectively heated and then oil quenched at the rate of one per second. Hardness at the cutting edge is Rc 62/64. Distortion is negligible.

Electronic Tube Generators from 1 kw to 100 kw.
Spark Gap Converters from 2 kw to 30 kw.

WRITE FOR THE NEW LEPEL CATALOG . . . 36 illustrated pages packed with valuable information.

All Lepel equipment is certified to comply with the requirements of the Federal Communications Commission.

LEPEL HIGH FREQUENCY LABORATORIES, INC.
55th STREET and 37th AVENUE, WOODSIDE 77, NEW YORK CITY, N. Y.

For more information circle **85** on inquiry card.

NEW Development!

HICKOK

250° Arc

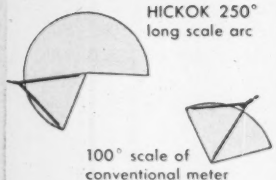
LONG SCALE METERS

Save Valuable Panel Space

The scale in these new instruments is 2½ times as long as conventional meters. A 3½" HICKOK 250° meter has a scale length equal to a conventional 6" instrument.

These exclusive panel style 250° meters fit a smaller space though still provide easier, more accurate readings.

Available in all popular AC or DC ranges. Square, semi-flush or round flush cases. 2½" thru 5½" sizes.

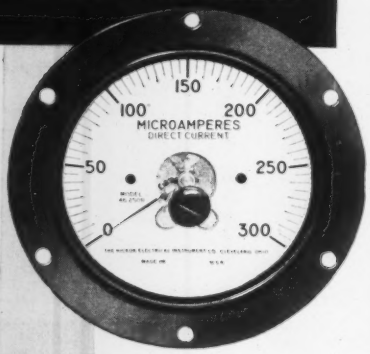


UNIFORM SCALE
Evenly Spaced Scale Divisions

RUGGEDIZED and SEALED

AC rectifier or DC types

The highly efficient HICKOK shock mount construction permits pointer and scale divisions to be easily read when meter is under vibration. The DC movement is a precise and rugged type. The AC movement is of the AC rectifier type with unusually efficient magnetic damping for ruggedized purposes. Case is permanently sealed at the factory, however, may be opened and resealed.



These instruments meet military specifications and are in volume production. Your inquiry is invited. Kindly list details of your requirements or request Catalog No. 37

THE HICKOK ELECTRICAL INSTRUMENT CO.

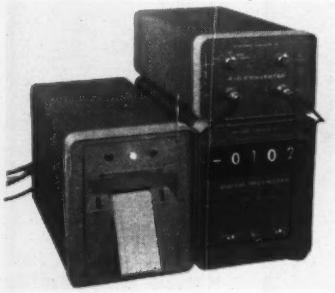
10519 DuPont Avenue • Cleveland 8, Ohio

For more information circle **86** on inquiry card.

NEW INSTRUMENTS

PORTABLE EDVM

New Digital Voltmeter Model 26.044 provides rapid four-digit readout of analog voltages with great accuracy. The self-contained unit has no stepping switches, is transistorized, and extensively uses printed-

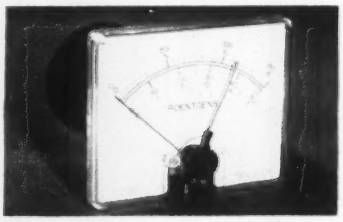


circuit wiring techniques. Three range scales are provided from 0 to 10, 10 to 100, and 100 to 1,000. Accuracy is 0.01% of full scale on all three ranges. Both positive and negative inputs can be read by the Digital Voltmeter and the input is automatically displayed on the front panel.—*Electronic Associates, Inc., Long Branch, N. J.*

For more information circle **188** on inquiry card.

MINIFIED CONTROL

New minified control, like most meter-relay controls, provides continual signal indication and when preset limits are reached, it triggers control action by appropriate equipment. For



manual reset operation, the new control may be used with 4½" API meter-relays. In such controls, the load relay is rated at 2 amps. For simple automatic operation, maximum sensitivity of meter-relays is approximately 200 microamps. Rating of the load relay in automatic circuits is 1 amp. —*Assembly Products, Inc., Chesterland, Ohio*

For more information circle **189** on inquiry card.

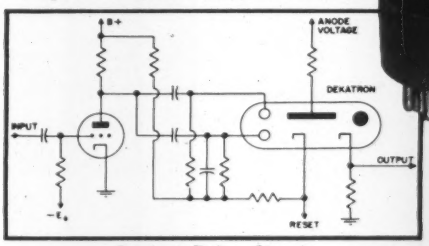
AC/DC DIGITAL VOLTMETER

New Model 402 Digital Voltmeter provides 100-microvolt resolution in d-c, 1-mv in a-c. It consists of three units which can be rack-mounted separately or together: (1) a Model 452

Simplify Circuitry using

dekatron®

Electronic Counting Tubes (up to 20,000 counts/sec.)



Typical Drive Circuit

As a user of DEKATRON cold cathode glow-transfer counting tubes, you are welcome to use this and many other drive circuits designed by us. Circuits are patented (or applied for) but are available to DEKATRON customers on a royalty-free basis.

Write to us for complete information.

Baird-Atomic, Inc.
33 UNIVERSITY RD., CAMBRIDGE 38, MASS.

Baird Atomic

Instrumentation for Better Analysis

For more information circle **87** on inquiry card.

King MANOMETERS

For Plant and Laboratory

King Manometers are rugged, low-cost instruments of unexcelled accuracy for measuring pressure, vacuum, differential pressure, and pressure-related phenomena. They're available in the following types, in a complete range of sizes:

U-Type Manometers

- Single Cleanout
- With 3-Valve Manifold
- Double Cleanout
- Inverted U-Type

Well-Type Manometers

- Low-Well
- Barometric-Reading
- Raised-Well
- Flowmeter Type
- Inclined-Tube

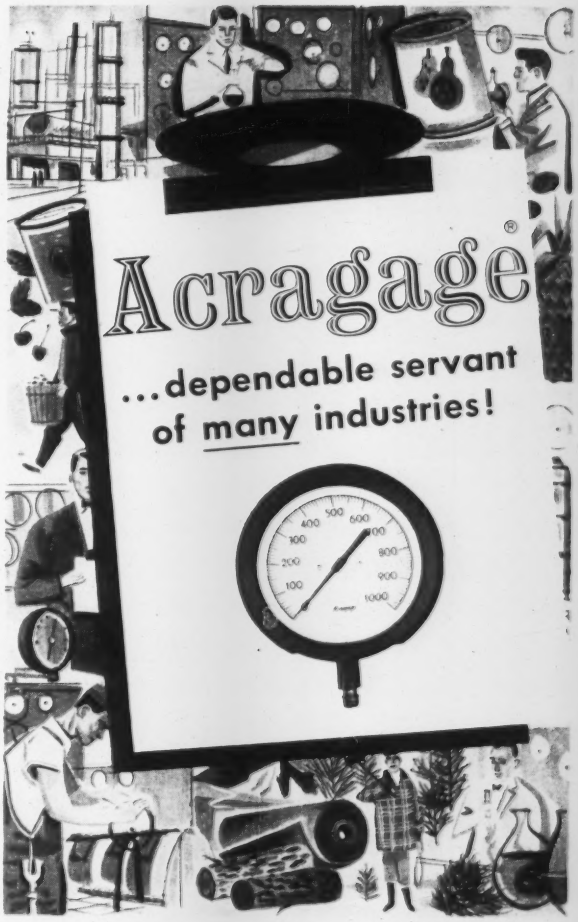
Multi-Tube Manometers

- Individual-Well
- Common-Well
- Photo-Manometers

NEW CATALOG 2008 gives details on these and other models—includes manometer liquids and accessories—explains basic principles. Write—

KING ENGINEERING CORP.
Box 70 • Ann Arbor, Mich.
REPRESENTATIVES IN PRINCIPAL CITIES

For more information circle **88** on inquiry card.



ACRAGAGES THRIVE ON THE TOUGHEST JOB DEMANDS IN THE PETROLEUM, PETRO-CHEMICAL, CHEMICAL, FOOD AND OTHER INDUSTRIAL FIELDS!

ACRAGAGES have achieved a reputation for unsurpassed dependability in a wide range of applications and industries. This reputation is a result of top quality workmanship and outstanding features such as the solid front case with full area rear blowout disc for positive protection, a longer Bourdon Tube, precision movements, and a choice of Tube materials. Acragage can fill your precise requirements with exactly the right gage for the job! Write for more information and latest bulletin!

ACRAGAGE GIVES YOU MORE GAGE PER DOLLAR

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Gentlemen: Please send me full information on Acragages and a copy of your latest Bulletin No. 191

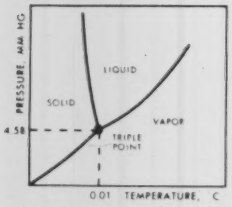
Name_____
Title_____
Firm_____
Address_____
City_____ Zone_____ State_____

For more information circle **89** on inquiry card.

Scientific Announcement

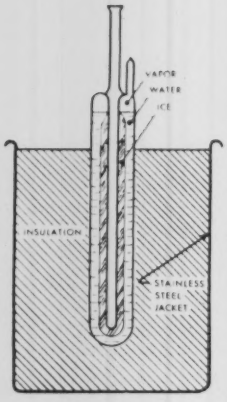
NEW PRIMARY STANDARD FOR TEMPERATURE

A new primary temperature standard, using the triple point of water, is now in use in national standards laboratories throughout the world. This new standard defines the triple point of water as 0.01°C. It has been recommended by the International Committee on Weights and Measures as the standard for the International Temperature Scale, and is already the standard on the thermodynamic scale (273.16K).



Phase Diagram for H_2O

The triple point of water is attained by partially freezing pure water in an evacuated and sealed glass system. A triple point of water cell maintains its true reference temperature of 0.01°C when ice, water and water vapor exist at 4.58 mm Hg.



Equiphase Cell

Triple Point Cells which meet the exacting requirements for use as a primary temperature standard are now available from Trans-Sonics,Inc. in a convenient, easy-to-use package. Called an Equiphase* Cell, this instrument is ideal for use in research laboratories, quality control and standards departments, or wherever a highly accurate and reliable primary temperature standard is required. Equiphase Cells come complete with full instructions for use, and are constructed so there is no possibility of contamination with consequent loss of accuracy. Write for Equiphase Cell Technical Bulletin to Trans-Sonics, Inc., Dept 19, Burlington, Mass.

*T.M.

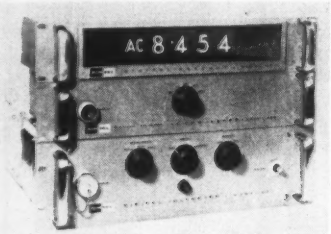
TRANS-SONICS T.M.

Precision Transducers

For more information circle **90** on inquiry card.

NEW INSTRUMENTS

A-C Converter, (2) a Model 451 Control Unit, and (3) a 471 Readout Unit. It features a unique projection-type automatic digital display and a built-in printer drive. D-c range is

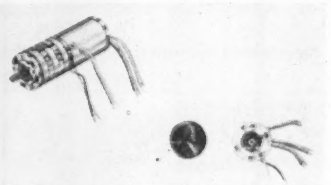


0.0001 to 999.9 in four automatic ranges; a-c range is 0.0001 to 999.9 v rms from 30 to 10,000 cps, in three manually-selected ranges.—*Kin Tel, a Div. of Cohu Electronics, Inc., 5725 Kearny Villa Rd., Box 623, San Diego 12, Calif.*

For more information circle **190** on inquiry card.

MOTOR-GENERATORS

New Size-8 Motor-Generator of 0.750" OD has tachometer-generator portion operating on either 18 or 26 v, 400 cps, and motor portion which

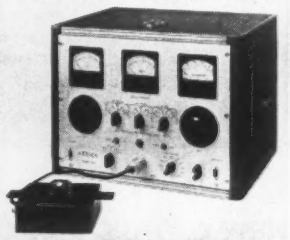


can be furnished with any combination of voltages up to 40 v on both the fixed and control phases, all 400 cps. —*G-M Laboratories, Inc., 4300 North Knox Ave., Chicago 41, Ill.*

For more information circle **191** on inquiry card.

RECTIFIER ANALYZER

New Metallic Rectifier Analyzers, S-100 Series, perform the following circuit tests for silicon, germanium and selenium metallic power recti-



fiers, and signal diodes: Visual dynamic voltage-current characteristic, dynamic reverse current-leakage, dynamic forward voltage-drop, static reverse current-leakage, and static forward voltage-drop.—4 page Bulletin R-250 contains details.—*Cedco Electronics, Inc., Erie, Penna.*

For more information circle **192** on inquiry card.

PHOTOELECTRIC CONTROL

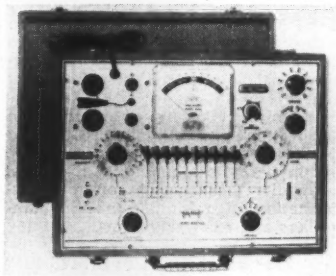
New light-energized tubeless control has a self-contained head using a cadmium cell as the light sensing ele-

ment. Operating requirements are 0.07 second dark-time and 0.07 second light-time with 10 foot-candles minimum light intensity.—*Autotron, Inc., Box 722 Q, Danville, Ill.*

For more information circle **193** on inquiry card.

TUBE TESTER

New Model 3414 Tube Tester tests receiving types, gaseous rectifiers, series filament, resistor and ballast tube continuity, neon indicators etc.

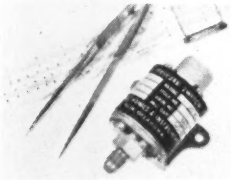


with great speed, as switch settings can be made before the tube warms up. Burned-out tubes are rejected instantly.—*The Triplett Electrical Instrument Co., Bluffton, Ohio.*

For more information circle **194** on inquiry card.

ABSOLUTE PRESSURE SWITCH

New absolute-pressure-type Miniature Precision Pressure Switches, Series 58,000, ranging from 1 to 350 psia are for automated machinery, but particularly suited to aircraft-



missile- and other ordnance-applications because of light-weight, compact design, accuracy and dependability even under extreme changes of environment or operating condition.—*Century Electronics & Instruments, Inc., 1333 North Utica, Tulsa, Okla.*

For more information circle **195** on inquiry card.

TRANS-SONICS

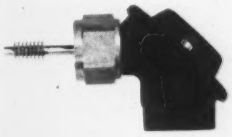
T.M.

PLATINUM TEMPERATURE TRANSDUCERS

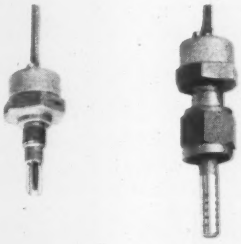
for measurement, telemetry, and control

- TEMPERATURES FROM −425 TO +1832 F.
- PRECISION CALIBRATION
- ACCURACIES TO 0.1 F.
- 5 VOLT OUTPUT
- HIGH RESPONSE SPEED

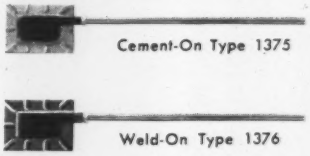
1300 Series



Type 2135



1350 Series Type 1321



Cement-On Type 1375

Weld-On Type 1376

BULB TYPE for corrosive gases and liquids

1300 Series transducers are available in ranges from −400 F to +1832F, feature 1% accuracy, stainless-steel construction, and a time constant of less than 2.5 seconds in agitated liquid. Many standard and special bulb lengths are available.

Type 2135 has ±0.25 F accuracy and interchangeability over a range of 0 to +125 F. The platinum element is enclosed in a nickel-plated bulb, and the unit will withstand a working pressure of 4500 psi.

OPEN TYPE for non-corrosive gases and liquids

1350 Series transducers are available in ranges from −300 F to +600 F, with an accuracy of ±1% full scale. The platinum sensing element comes in direct contact with the gas or liquid being measured, resulting in a typical response time of 0.2 second in agitated liquid.

Type 1321 is designed for extreme low temperature measurements, with special calibrations to −425 F. Operating interval is 30 F in ranges up to +250 F, with ±1% accuracy. A perforated shield protects the platinum sensing element from high flow rates.

SURFACE TYPE for all kinds of surfaces

These platinum temperature transducers can be installed by a variety of methods on any surface . . . flat or curved, metallic or non-metallic. The following types are available in ranges from −400 F to +1850 F: Cement-On, Weld-On, Tape-On, Thermopaper, Sub-Surface, and Surface Transferable.

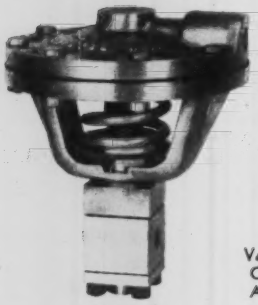
A five-point resistance-temperature calibration certificate at 0, ¼, ½, ¾, and full scale temperature is supplied with each transducer. Custom designs for all temperature transducers are available on special order with accuracies to 0.1 F. Write to Trans-Sonics, Inc., Dept. 19, Burlington, Mass. for Condensed Catalog on Platinum Temperature Transducers.

TRANS-SONICS

Precision Transducers

For more information circle **91** on inquiry card.

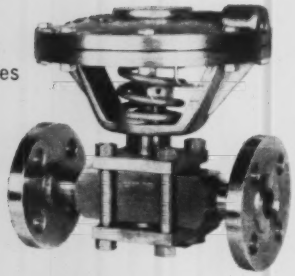
MINIATURE VALVES



501 Series

Valves Shown One-Fourth Actual Size

526 Series



RUGGED

"BANTAM"

THROTTLING CONTROL VALVES

Compact throttling controls of the 501 series have one-piece barstock bodies with screwed ends and are available with linear, equal percentage or quick-opening plug characteristics. This series offers six operators, direct and reverse acting, including two with positioners.

The 526 series includes 6 body styles in globe, angle and 3-way design — with screwed or flanged ends. Four bonnet types cover standard, high or low temperature and packless applications. Six control operators are offered with up to 50 square-inch diaphragms.

	501	526
Pressure Rating	1000 psi (at 450°F)	1000 psi (at 450°F)
Temperature Rating	−70°F to +450°F	−70°F to +450°F (750°F with finned bonnet)
Maximum Cv.	0.63	10.0 (1" connections)
Lift	¼"	7/16"
Seat Area	0.038 sq. in.	up to 0.601 sq. in.
Connections	⅛", ¼", ½" N.P.T. Standard (others available)	¼" to 1" N.P.T. ½" to 1" flanged

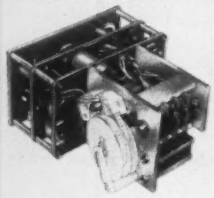
Send for the BANTAM Catalog No. B-1 and other technical data on Dahl pneumatic and hydraulic valves.

George W. Dahl Company, Inc.
86 Tupelo Street
Bristol, Rhode Island

For more information circle **92** on inquiry card.

A/D MILLIVOLT METER

New BH 180 AutoTemp and BH 170 AutoTak Series analog-to-digital Indicating Millivolt Meter, a servo-driven potentiometric unit with labo-



ratory accuracy of 1/10%, has digital readout from 144-inch tape-slidewire and programming contacts, transistorized amplifier, and Zener-referenced power supply.—*B&H Instrument Co., Inc. 3479 West Vickery Blvd., Fort Worth 7, Texas*

For more information circle **196** on inquiry card.

PICK-UP ATTENUATORS

New portable Transmission Line Pick-Up Attenuators, Type 5890-A and Type 5890-B, allow measurement of transmitter frequencies directly from the transmission line. This is necessary when the antenna is not directly accessible or the signal is too weak to be received by a frequency-meter antenna pick-up. Maximum attenuation is 100db and minimum attenuation is 40 db in the 25- to 54-Mc band. In the 450-Mc band maximum attenuation is 80 db and minmium attenuation is 35 db.—*Allen B. DuMont Laboratories, Inc., Mobile Communications Sales Dept., 760 Bloomfield Ave., Clifton, N. J.*

For more information circle **197** on inquiry card.

TURNS COUNTER

New three-digit Turns Counter has knob which mounts on the component adjusting shaft and operates both

shaft and counter. Each one-hundredth clockwise revolution adds one full-unit count on the counter; each one-hundredth counter-clockwise revolution subtracts one full-unit count. The counter continuously gives direct digital reading of the shaft position in one-hundredth turns. Standard units are furnished for ⅛ or ¼" component shaft dia.—*Production Instruments Div., General Controls Co., 8062 B McCormick Blvd., Skokie, Ill.*

For more information circle **198** on inquiry card.

NEW *transistorized* PHASE METER

TYPE 328-A

By ACTON LABORATORIES

•

FREQUENCY RANGE FROM 10 CPS - 50 KC

•

PHASE ACCURACY 1° FROM 10 CPS - 10 KC

•

LONG-TIME STABILITY

FEATURING... Direct reading from 0° to 360° in 6 ranges of 60° each (on a 5" meter scale).

Type 328-A is designed specifically to measure the phase angle in degrees between two sinusoidal or non-sinusoidal voltages within a frequency range from 10 cps to 50 kc. It is capable of handling a wide variety of applications in the field of audio facilities, supersonics, servo-mechanisms, geophysics, vibrations, acoustics, aerial navigation, electronic power, transformation, signalling, computing amplifiers and resolver systems.

SPECIFICATIONS

Amplitude Range — .25 to 170 volts peak (1 volt min. below 500 cps)

Phase Accuracy — For input signals above 10 volts peak from 10° to 350°: 1° at 10 cps — 10 kc; 2° at 10 kc — 30 kc; 3° at 30 kc — 50 kc

Input Impedance — One megohm shunted by 20 mmf

Recorder Output — Maximum voltage at 360° is — 2.0 volts. Internal output impedance is approximately 100,000 ohms

Power Supply — 105-125 volts, 60 cycles A.C. Total power consumption is approximately 20 watts.

Terminals are also provided for operation from an external 45-volt battery.

Accessories available — Pre-amplifiers (10 to 1) and improved ½° accuracy from 10 cps to 10 kc.

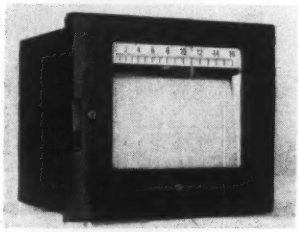
Complete technical details on Type 328-A Phase Meter are available on request

ACTON LABORATORIES, INC.
A subsidiary of Technology Instrument Corp.
533 MAIN STREET, ACTON, MASS.
COlonial 3-7756

For more information circle **93** on inquiry card.

STRIP CHART RECORDER

New null-balance strip chart recorder-controller features continuous standardization by silicon (Zener) diode, and unitized construction, with printed circuits and plug-in components. Available as d-c potentiometers,

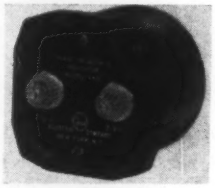


a-c or d-c bridge; and both single-pen (type HF) and multi-record (type HG) types, it has 10¾" calibrated chart width. The new instrument can be used to record watts, vars, power factor, and frequency, or pH conductivity, temperature, flow and pressure.—*General Electric Co., Schenectady 5, N. Y.*

For more information circle **199** on inquiry card.

PHASE SEQUENCE INDICATOR

New panel-mounting Model VA5 Phase Sequence Indicator provides a means of instantly determining the order in which the voltage peaks oc-

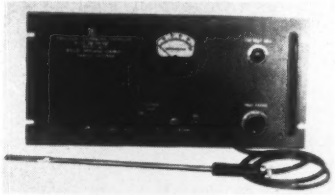


cur in a three-phase, 115-volt, 400-cycle power line. Voltage range is 75 to 135 rms and frequency range is 300 to 500 cps.—*Opad Electric Co., 69 Murray St., New York 7, N. Y.*

For more information circle **200** on inquiry card.

TEMPERATURE CONTROLLERS

New Standard Relay Rack Models, Series 230, feature a true resistance-thermometer/electronic-bridge-circuit design. Control accuracy of ±0.001°



C includes the resistance-thermometer probe. Model 238 (illustrated) has power-proportioning control mode. Other models are made with on-off control.—*Bayley Instrument Co., Box 538, Danville, Calif.*

For more information circle **201** on inquiry card.

GULTON SHOCK AND VIBRATION DATA FILE

How to simplify measurement of shock and vibration

Basically, the solution to more accurate shock and vibration measurement lies in the application of completely integrated sub-systems as against combinations of individually specified components.

SYSTEM MATCHING A PROBLEM

The disadvantages associated with properly matching the individual sections of a measurement sub-system are many.

Figure 1 shows typical specifications for a sub-system comprising accelerometer, cathode follower, filter, amplifier, cables and connectors, and power supply.

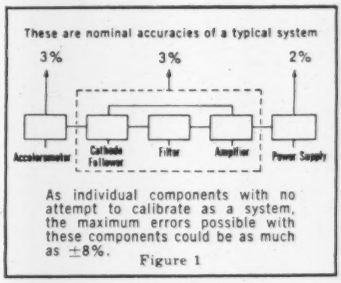

These are nominal accuracies of a typical system
3%
3%
2%
Accelerometer
Cathode Follower
Filter
Amplifier
Power Supply
As individual components with no attempt to calibrate as a system, the maximum errors possible with these components could be as much as ±8%.

Figure 1

Note that while accuracy of individual components may be ±3% maximum over-all system accuracy can only be calculated within ±8%. Need for improving system accuracy thus results in over-specification of component parts, consequent loss of frequency range and sensitivity, and usually, greater expense.

The most obvious disadvantage of this method is the inherent difficulty and loss of time spent in finding and matching component sections most compatible with each other—as well as the difficulties of dealing with more than one supplier.

ADVANTAGES OF COMPLETELY INTEGRATED SUB-SYSTEMS

The function of any shock and vibration measurement sub-system is to provide a signal proportional to the actual acceleration encountered.

Albert Gillon, Senior Engineer Calibration Laboratory

Much higher levels of accuracy can be established — indeed guaranteed —with no sacrifice of range or sensitivity with complete design and integration by one responsible organization.

As a rule, system performance can be further improved, in terms of weight and size, by the possibility of eliminating certain components, as for example cables and connectors, through the system design. Filter circuits can be incorporated in the amplifier.

SIMPLE CALIBRATION

Still another and very important advantage is that of easy calibration. In a Gulton integrated sub-system, component parts are designed with maximum compatibility—and are calibrated as an over-all system to provide the required full range of outputs. Provision can be made for field-calibrating the entire system through just two connection points —reducing preparation test time to a minimum.

SEND FOR TECHNICAL DATA

For more complete information on Gulton *completely integrated* measurement systems, contact your local Gulton representative, or write us direct.

CALL ON GULTON FOR FREE TECHNICAL SERVICE

Because Gulton designs and supplies completely integrated sub-systems for shock and vibration measurement, we can fully understand your problems. You are invited to put this extensive knowledge and experience to work for you.

GULTON INSTRUMENTATION DIVISION

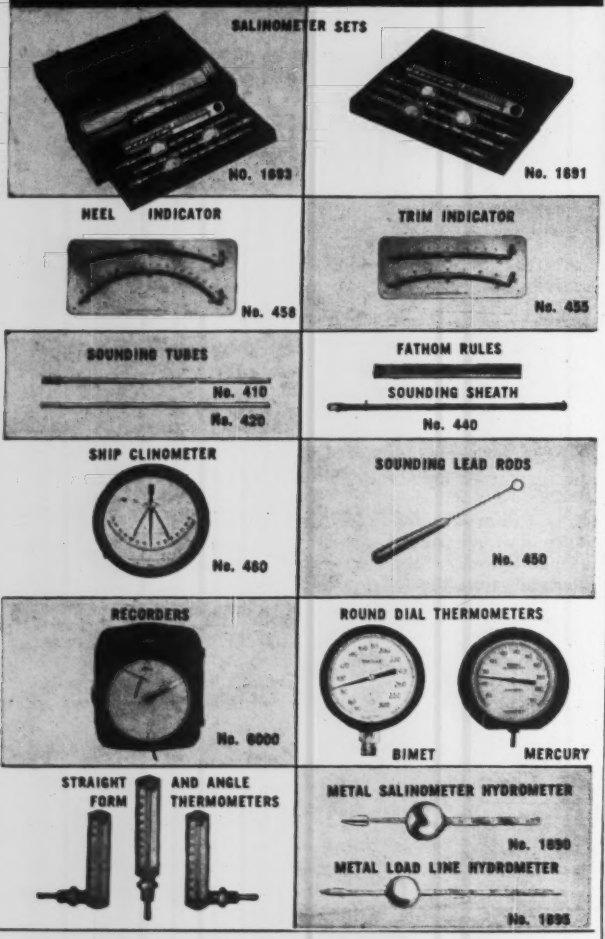
Gulton Industries, Inc.

Metuchen, New Jersey

In Canada: Titania Electric Corp. of Canada, Ltd., Gananoque, Ont.

For more information circle **94** on inquiry card.

MOELLER MARINE INSTRUMENTS



THE ACME OF GUARANTEED ACCURACY AND DEPENDABILITY

On deck, and in cabin, or engine room to indicate temperature readings, or to take soundings —whether to measure fathoms, or determine trim and heel, Moeller Marine Instruments have set the standard of accuracy for dependability in the Marine field for more than half a century.

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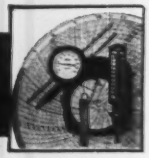

Gentlemen: Without obligation, please send me Moeller Bulletin, "Especially for ships."

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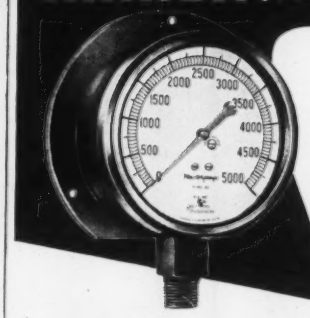
For more information circle **95** on inquiry card.

MARSH *Mastergauge*



The gauge that has everything!

- **LEAK-PROOF ONE-PIECE CONSTRUCTION** . . . bourdon tube fused to socket and tip by exclusive "Conoweld" process.
- **STURDY "MARSHALLOY" CASE** . . . formed of boiler-plate-thickness steel, copper clad inside and outside to give it the corrosion resistance of solid copper. It's one third lighter, but four times stronger than cast iron.
- **PRECISION "MASTERGAUGE" MOVEMENT** . . . with such exclusive features as the coined sector gear.
- **AVAILABLE WITH STAINLESS TUBE AND SOCKET** . . . choice of stainless steels and alloys for all corrosive conditions.
- **WITH "RECALIBRATOR"** . . . quickest and best way to keep a gauge accurate.

These features are combined only in "Mastergauge", standard bearer for the broad line of Marsh Gauges . . . each the best of its kind. Ask for data.

MARSH "THE STANDARD OF ACCURACY"

MARSH INSTRUMENT CO., *Sales Affiliate of Jas. P. Marsh Corp.* **Dept. 42 Skokie, Ill.**
Marsh Instrument and Valve Co. (Canada) Ltd. 8407 103rd St., Edmonton, Alberta.
Houston Branch Plant: 1121 Rothwell St., Sect. 15, Houston, Texas.

For more information circle **96** on inquiry card.

GREEN *Pantograph Engravers*

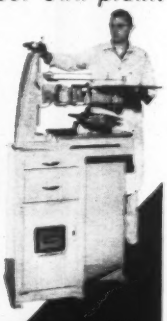
ELIMINATE DELAYS!
Keep the work in your own plant.

PORTABLE 40-POUND BENCH-MODEL 106

Famous 2 or 3-dimensional engraver, successfully used by thousands, features 5 positive, accurate pantograph ratios. Versatile ball bearing spindle has three speeds up to 14,000 rpm; height of pantograph and position of cutter are continuously adjustable; one copy carrier (supplied) accepts all standard master type sizes.

The Model 106 has proven incomparable for speed and accuracy . . . yet reasonably priced.

Cutter grinders, rotary tables, master letters, compound slides, name plates and all required accessories. For complete information, write to



MODEL D2 HEAVY-DUTY 2-DIMENSIONAL

- 675 pounds — rigid, sturdy, precise
- Vertical adjustment of copy table automatic with Pantograph
- Unobstructed on three sides to take large work
- Micrometer adjustment for depth of cut
- Ball-bearing construction throughout — super-precision ball bearing spindle
- Spindle speeds up to 26,000 rpm for engraving or machining modern materials
- Ratios 2 to 1 to infinity
- master copy area 24" x 30"
- Vertical range over 20"

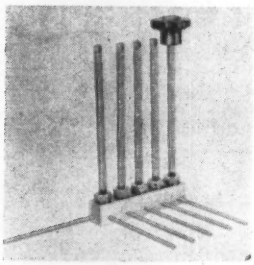
GREEN INSTRUMENT COMPANY, INC.

383 PUTNAM AVENUE, CAMBRIDGE 39, MASS.

For more information circle **97** on inquiry card.

PACKLESS VALVE MANIFOLD

New Packless Valve Manifold consisting of 5 valves having 0.0006 cu-in volumetric displacement is de-

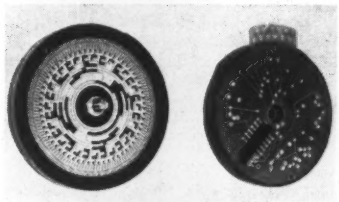


signed primarily for gas chromatography and can be cam-actuated for programming applications.—*George W. Dahl Co., Inc., 86 Tupelo St., Bristol, R. I.*

For more information circle **202** on inquiry card.

A/D SHAFT CONVERTER

New miniaturized 10-bit analog-to-digital Shaft Converter incorporates high resolution in combination with positive ambiguity elimination. The

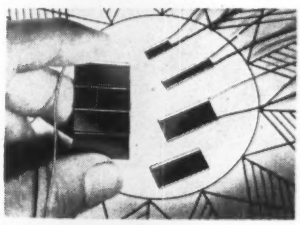


3-½-inch disc yields up to 1024 position reports, permitting, for example, the control of linear machine feeds to tolerances of 0.001 of the travel.—*Librascope, Inc., 808 Western Ave., Glendale 1, Calif.*

For more information circle **203** on inquiry card.

SILICON SOLAR CELLS

New Silicon Solar Cells are capable of converting 10% and more of the radiant energy falling on their surface. Meeting MIL specs, they are

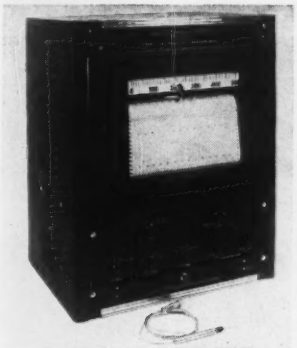


capable of providing an output of approximately 9 watts/sq ft of active cell area in bright sunlight. Individual cells are obtainable, with or without color-coded pigtail leads, in sizes ½x1 cm, ½x2 cm, and 1x2 cm.—*International Rectifier Corp., 1521 E. Grand Ave., El Segundo, Calif.*

For more information circle **204** on inquiry card.

TEMPERATURE RECORDER

New Model 102, using a Brown Instrument strip chart recorder, has a thermistor sensing element and a

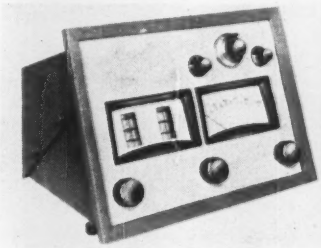


sensitivity and accuracy of 0.001°C on a full scale of ½°C. By means of a selector switch and ½°C portion of the range can be recorded accurately.—*Fenwal Electronics, Inc., Mellen St., Framingham, Mass.*

For more information circle **205** on inquiry card.

GAS ANALYZER

New Therma Bridge Gas Analyzer incorporates a unique new hexagonal open-core sensing cell to provide im-

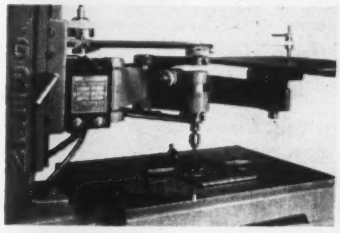


proved thermal dissipation, and features transistor-regulated power supply.—*Industrial Instruments Engineering Corp., 89 Commerce Rd., Cedar Grove, N. J.*

For more information circle **206** on inquiry card.

ENGRAVER

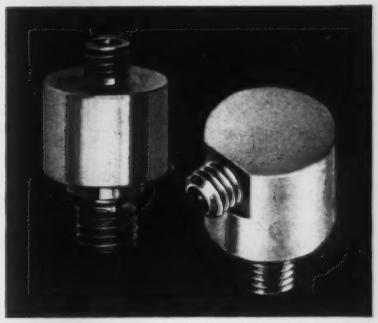
New Engraver, Model D-2, now available with air cylinder attachment for high-speed drilling of printed



circuits, provides ratios from 2:1 to infinity. Up to 100 holes per min can be drilled by unskilled operators.—*Green Instrument Co., 385 Putnam Ave., Cambridge, Mass.*

For more information circle **207** on inquiry card.

Avoid false test results with GLENNITE internally ungrounded accelerometers



Now you can avoid one of the major causes of false test results – spurious "ground loop" voltages – by using *internally ungrounded* GLENNITE accelerometers.

These units contain sensitive seismic elements *internally* insulated from the mounting stud by rugged ceramic insulation. You can employ a *single point ground* at the data handling or recording equipment by using a combination of these accelerometers with ungrounded GLENNITE amplifiers and filters.

GLENNITE accelerometers are available in uni- and triaxial models – wide acceleration and temperature ranges.

A complete line of associated ungrounded electronic equipment includes filters, amplifiers, connectors and other related units.

For complete data on Gulton instrumentation systems – grounded or ungrounded – contact your local Gulton representative or write us direct.

Call in Gulton

From transducer to readout, Gulton is capable of meeting all your instrumentation needs. If you have a measurement problem, why not call in a Gulton Instrumentation Engineer. His broad experience in shock and vibration measurement can prove invaluable to you.

GULTON INSTRUMENTATION DIVISION

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For more information circle **98** on inquiry card.

ARE YOU PROPERLY GEARED FOR

MINIATURIZATION?

SMALL DRILLS MUST BE HELD IN PRECISION COLLETS TO ASSURE ACCURACY

A super-sensitive drill press in which drills are held in precision collets to eliminate chucking errors. Table is keyed to prevent any play. Feed is by raising table. No quill to cause drag.

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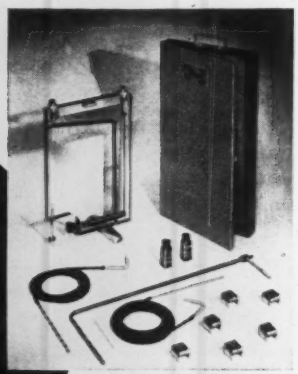
For more information circle **99** on inquiry card.

Dwyer CONTROLS GAGES

AIR VELOCITY METER No. 400

One Instrument Tells Both Air Velocity and Static Pressure!



- **Reads directly in feet per minute and inches of water.**
- **Check *all* velocities from 400 to 10,000 F.P.M.**
- **All static pressures from 0 to 10″ of water.**

Tests fan and blower discharge and inlet pressures, pressure drop across filters, balances air conditioning systems, etc. Complete kit includes dual purpose manometer, 18″ stainless steel pitot tube, Magneclips and all necessary fittings, tubings, instructions and accessories.

Write today for literature and prices.

F. W. DWYER MFG. CO.

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For more information circle **100** on inquiry card.

A. D. JONES OPTICAL WORKS

2400 MASSACHUSETTS AVENUE
CAMBRIDGE 40 MASSACHUSETTS
TRowbridge 6-3368—3369

A LIST OF MATERIALS WE FABRICATE USED IN OPTICS AND ELECTRONICS

SAWING GRINDING POLISHING DRILLING

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ARSENIC TRISULPHIDE
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BISMUTH
BRASS
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CERAMIC
COPPER
*CORNING 707
*CORNING 7052
FERRITE
FERROX
**FLUORIDE, CALCIUM
**FLUORIDE, LITHIUM
GERMANIUM
INDIUM ANTIMONITE
INDOX
MELAMINE FIBER GLASS
MICA, SYNTHETIC
POTASSIUM BROMIDE
*PYREX
*QUARTZ, CRYSTAL
*QUARTZ, FUSED
**SAPPHIRE
**SODIUM CHLORIDE
**STEEL
STRONTIUM TITANATE
TITANIUM DIOXIDE
*VYCOR
*X-RAY LEAD GLASS
ALL TYPES KNOWN GLASS

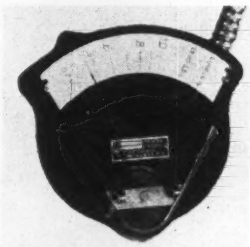
*Carried in stock
**Purchased for orders

For more information circle **101** on inquiry card.

NEW INSTRUMENTS

VANE-TYPE FLOWMETER

New line of vane-type Flowmeters for higher pressures has magnetically-coupled pointers avoiding packing glands and there is no drag to interfere with operation or meter ac-

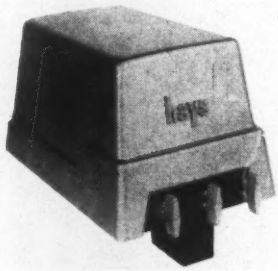


curacy. Pressure range is from 60 to 2000 psig. Meters for scale ranges up to 10 cfm and 20 gpm are available for direct installation into the piping; shunt-type flowmeter assemblies are used for larger flows.—*Seico Instruments Div., Eclipse Fuel Engineering Co., Rockford, Ill.*

For more information circle **208** on inquiry card.

FLOW TRANSMITTERS

New aneroid Flow Transmitter, Model 245, for measuring flow, liquid level, or differential pressures has no torque tubes, stuffing boxes, knife

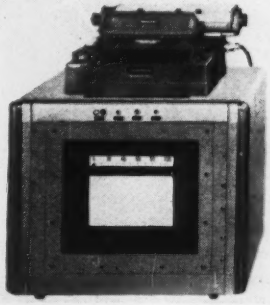


edges or bearings, and is entirely mechanically frictionless. Specifically designed for use with the new Universal Electronic Recorder its ranges are from 20" to 600" WC. Mounting is on 2-in pipe or wall.—*Hays Corporation, Michigan City, Ind.*

For more information circle **209** on inquiry card.

DATA LOGGERS FOR FLOW

New Data Logging System includes Model 166, which has a 48-point scanner with a single-range typewriter readout, and Model 167 with the necessary additional circuitry for multi-range selection. Analog signals from

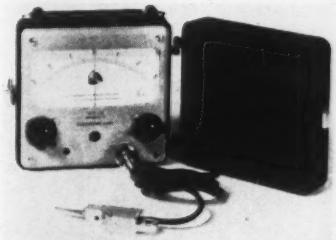


temperature, strain, flow, pressure, level, vibration, and other transducers are converted to typewritten data on 11-in sheets or continuous lengths. The measuring system incorporates a strip chart potentiometer recorder so that data may be scanned and printed vs time on a strip chart in addition to typewritten record.—*Gilmore Industries, Inc.*, 13015 *Woodland Ave., Cleveland* 20, *Ohio.*

For more information circle **210** on inquiry card.

TRANSISTORIZED INDICATOR

New portable Type 170 MICROtrol Transistorized Indicator is battery-powered. Provides full-scale ranges of 0.0006" (magnification 7700X) and



0.006" (magnification 770X). "Gage-laboratory" accuracy for the most critical gaging applications is claimed. —*Airborne Instruments Lab.*, 160 *Old Country Rd., Mineola, N. Y.*

For more information circle **211** on inquiry card.

525° F plus internal ungrounding

You get both in this Glennite® piezoelectric accelerometer

Now, for the first time, you can have extremely high temperature range *plus* the advantage of *internal* ungrounding.

Heretofore supplied grounded, the AXT321 is now available for applications where "ground loops" must be avoided.

The new ungrounded AXT321TMU, developed for use in extreme environments, can be operated continuously without temperature compensation.

It has excellent accuracy and reliability, high resonant frequency, small size, light weight.

A complete line of associated equipment is available including filters, amplifiers, connectors and other related items.

For complete data, call your local Gulton representative or write us direct.

Acceleration Range:	0.1 to 300 g
Frequency Range	
at room temperature:	3 to 3000 cps
at +525°F:	10 to 3000 cps
Resonant Frequency:	10,000 cps
Capacitance:	500 μμf
Temperature Ranges:	—100° F. + 525°F
Sensitivity:	5 mv/g min.
Weight (Approx.):	5.5 grams

Call In Gulton

From transducer to readout, Gulton is capable of meeting all your instrumentation needs. If you have a measurement problem, call in a Gulton Instrumentation Engineer. His broad experience in shock and vibration measurement can prove invaluable to you.

GULTON INSTRUMENTATION DIVISION

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Metuchen, New Jersey

In Canada: Titania Electric Corp. of Canada, Ltd. Gananoque, Ontario

For more information circle **103** on inquiry card.

TANK-O-METER

FOR MEASURING TANK CONTENTS ANY DISTANCE AWAY

TANK MAY BE BURIED, ELEVATED, OPEN, CLOSED, VENTED OR UNDER PRESSURE OR VACUUM

SEND FOR BULLETINS

Also gauges for:
Barometric Pressure (Mercury Column)
Absolute Pressure (Mercury Column)
Pressure and Vacuum
Differential Pressure
Inclined Manometers for draft, pressure or differential pressure.

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For more information circle **102** on inquiry card.

HEISE GAUGES

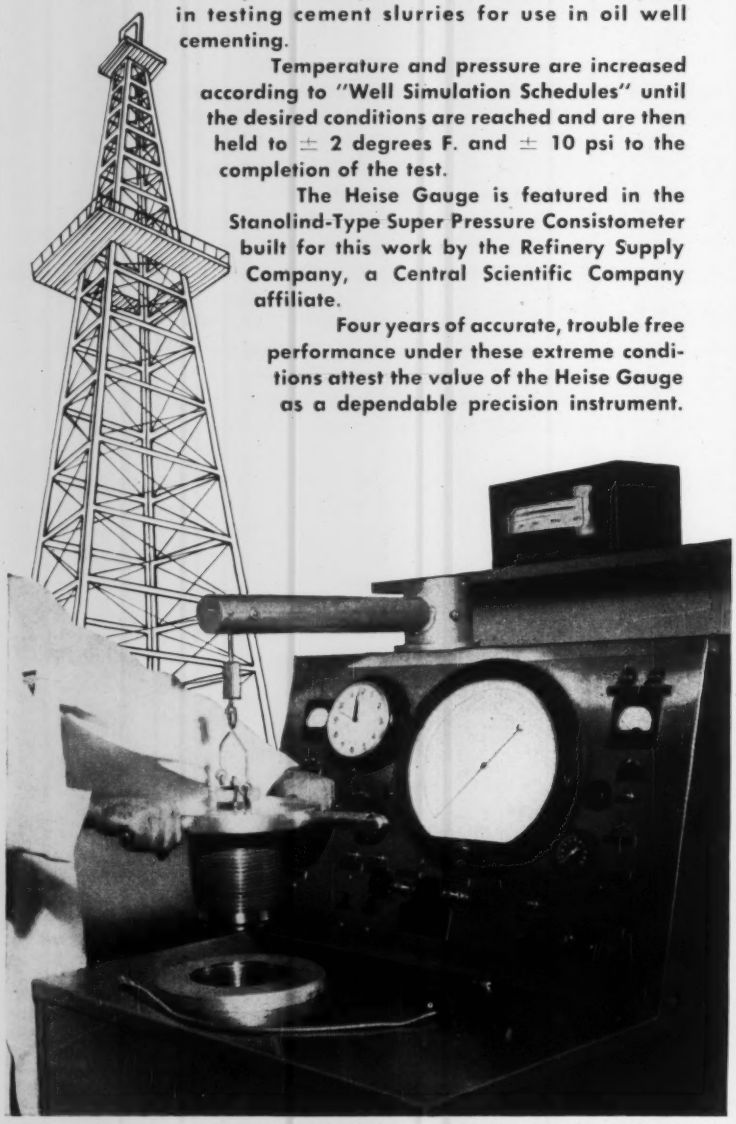
Indoor Oil Well

Pressures up to 20,000 psi at temperatures to 350 degrees F., encountered deep in the earth, are reproduced under laboratory control by the Continental Oil Company in testing cement slurries for use in oil well cementing.

Temperature and pressure are increased according to "Well Simulation Schedules" until the desired conditions are reached and are then held to ± 2 degrees F. and ± 10 psi to the completion of the test.

The Heise Gauge is featured in the Stanolind-Type Super Pressure Consistometer built for this work by the Refinery Supply Company, a Central Scientific Company affiliate.

Four years of accurate, trouble free performance under these extreme conditions attest the value of the Heise Gauge as a dependable precision instrument.



Pressure Ranges 15 to 20,000 P.S.I. Dial Sizes 8½"-12"-16"

Prices from $166.75 **DELIVERY WITHIN 30 DAYS**

HEISE BOURDON TUBE COMPANY, INC.

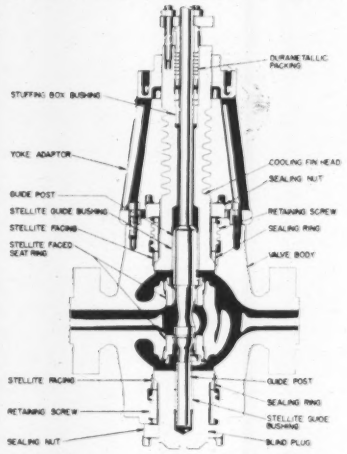
BROOK ROAD, NEWTOWN, CONNECTICUT, U.S.A.

For more information circle **104** on inquiry card.

NEW INSTRUMENTS

HIGH-PRESSURE VALVES

New HH series of double-ported 2500-pound valve bodies for high-pressure, high-temperature service

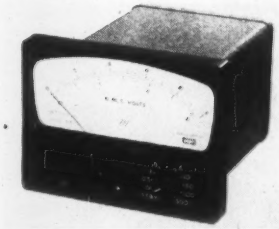


features pressure seal joints (instead of the conventional head and blind flanges), fully-stellited seat rings, and solid cast-stellite guide bushings. —*Fisher Governor Co., Marshalltown, Iowa*

For more information circle **212** on inquiry card.

MINIFIED VTVM

New 6" panel-mounted electronic voltmeters, Models 300 (DC) and 310 (AC) with 5-⅛" scale are are completely self-contained units whose high input impedance enables them



to measure voltage in a circuit without loading it. The d-c voltmeter, with accuracy of ±3% of full scale deflection, is available in seven discrete ranges, from 1 to 1000 v. The a-c model, with frequency response from 20 cps to 100 kc, offers 10 ranges from 30 mv to 300 v rms. Input impedance is 1 megohm, 30 uuf.—*Metronix, Inc., Chesterland, Ohio*

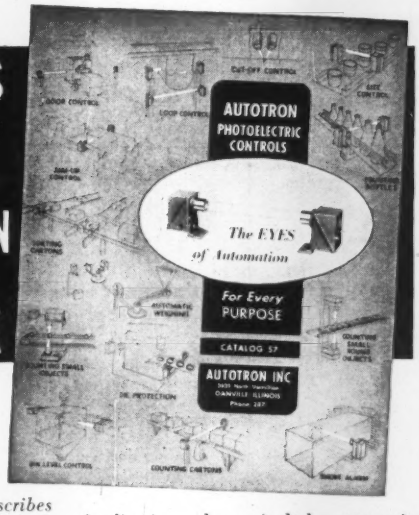
For more information circle **213** on inquiry card.

ELECTRONIC INTEGRATOR

New Electronic Integrator incorporates velocity-servo principle and features rapid frequency response, stability, and linearity. Comprises a servo amplifier, a velocity-tachometer, and a power supply packaged in a light steel cabinet.—*Bell Automation Corp., 749 Monroe Ave., Rochester 7, N. Y.*

For more information circle **214** on inquiry card.

EYES of AUTOMATION at WORK



New catalog describes normal, high speed, ultra sensitive and impulse actuated photoelectric controls with safety relays, warm up protection, etc. Also photoelectric timing controls, and wide selection of light sources with many protective features.

Send for your personal copy

Applications shown include automatic control of conveyors, inspection, carton sorting, smoke and fire detection, die protection, counting, weighing, limit control, tension control, car washing control, piling to exact count, safety control, conveyor traffic and jam-up control, timing control, control of spraying equipment, ramp traffic control and others.

AUTOTRON, INC.

3629 North Vermillion

Box 722QW Danville, Ill.

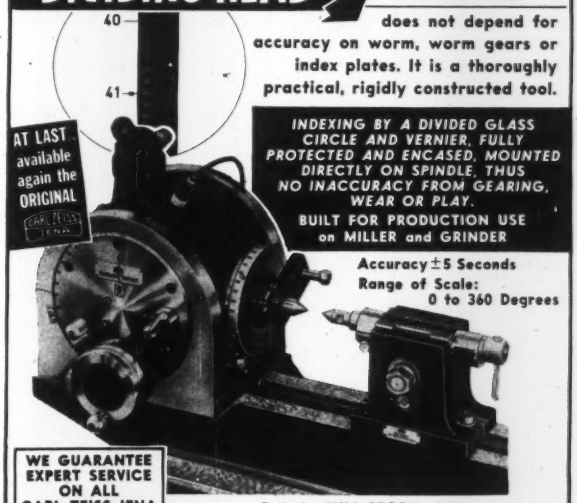
For more information circle **105** on inquiry card.

NEW CARL ZEISS JENA

OPTICAL DIVIDING HEAD

PERMITS PRESETTING TO ANY DESIRED MINUTE AND SECOND FACTOR FOR NEXT OPERATION WHILE FIRST OPERATION IS IN PROGRESS

does not depend for accuracy on worm, worm gears or index plates. It is a thoroughly practical, rigidly constructed tool.



AT LAST available again the ORIGINAL CARL ZEISS JENA

INDEXING BY A DIVIDED GLASS CIRCLE AND VERNIER, FULLY PROTECTED AND ENCASED, MOUNTED DIRECTLY ON SPINDLE. THUS NO INACCURACY FROM GEARING, WEAR OR PLAY.

BUILT FOR PRODUCTION USE on MILLER and GRINDER

Accuracy ±5 Seconds

Range of Scale: 0 to 360 Degrees

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200 MG LAFAYETTE STREET • NEW YORK 12, N. Y.

For more information circle **106** on inquiry card.

EPLAB

PYRHELIOMETER

For the Measurement of SOLAR RADIATION

Eppley Pyrheliometers are used for solar radiation measurements at ninety-eight weather stations in the continental United States, Canada, Alaska, Greenland, Iceland, Caribbean Sea, and the Pacific Ocean. Sixty-two of these stations are under the direction of the United States Weather Bureau.

The Eppley Pyrheliometer was adopted as standard equipment by the Weather Bureau after considerable experimentation. It was found to be the best instrument so far tested by the Bureau.

Used in conjunction with a suitable recorder, the Eppley Pyrheliometer will provide an accurate and reliable record of total solar and sky radiation on a horizontal surface.

Bulletin No. 2 on Request

THE EPPLEY LABORATORY, INC.

Scientific Instruments

2 Sheffield Ave.

Newport, Rhode Island U. S. A.

For more information circle **107** on inquiry card.

SPAGHETTI SLEEVING

MADE FROM

TEFLON*

is Carefully Inspected and Controlled Dimensionally!

● PF spaghetti sleeving made from Teflon* is widely used for slip-on insulation, instrument tubing, bundle sheathing, medical tubing, pigtails and similar applications. It slips on easily, in long lengths up to 3 feet, can be used with tinned or bare wire rather than silvered and it wears longer. 25 sizes, 2 wall thicknesses, 10 colors in stock, 100% inspected and controlled dimensionally, are available, all with these important advantages:

- good dielectric strength (500 to 2000 volts/mil)
- lowest dielectric constant (2.0) and dissipation factor (0.0002) of any solid dielectric
- no change of electrical properties with temperature (—25°C to +250°C) or frequency (60 cycles to 100 mc)
- zero moisture absorption
- unaffected by any commercial chemical
- stress relieved for negligible shrinkage
- continuous service temperature of 250°C—intermittent to 300°C

Write, wire or call for further details and engineering assistance. Ask, too, for information on PF Teflon* flexible tubing, heavy-walled tubing and rod stock.

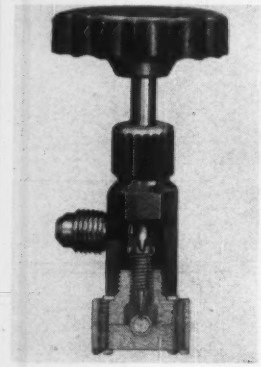
PENNSYLVANIA FLUOROCARBON CO., INC.
1115 N. 38th Street, Phila. 4, Pa. EVergreen 6-0603
*Teflon—DuPont trade name for Tetrafluoroethylene resin

For more information circle **108** on inquiry card.

NEW INSTRUMENTS

TUBE-TAPPING VALVES

New small and inexpensive tube-piercing-and-tapping Valves, including line-tap, line-port, can-tap and control valves for refrigeration, air conditioning, and industrial applications are suitable for use with aluminum, copper or steel tubing. Being essentially two valves employed together to pierce lines or cans, the control valve is removable, leaving the line-tap or can-tap valves in place for further use. Illustrated is a CV-1 Angle Control Valve showing method of operation with the line tap valve.—*Henry Valve Co., 3215 North Ave., Melrose Park, Ill.*



For more information circle **215** on inquiry card.

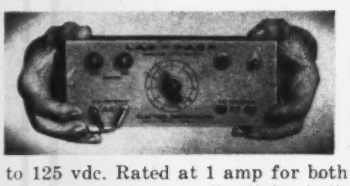
QUICK-RESET COUNTER

New Model 1523 high-speed quick-reset geared Revolution Counter accepts speeds up to 6,000 rpm or 8,000 counts per min.—*Veeder-Root Inc., Hartford 2, Conn.*

For more information circle **216** on inquiry card.

VARIABLE POWER PACK

New Lab-Pack, laboratory power pack, features a-c and d-c variable output control 0 to 130 vac or from 0 to 125 vdc. Rated at 1 amp for both ac and dc it has a pilot-light indicator, on-off switch, and test leads.—*Electrol Specialties, 441, Clark St., South Beloit, Ill.*



For more information circle **217** on inquiry card.

For your library . . .

Printed Circuitry

by Allan Lytel. A valuable working tool; includes alternative and recommended practice for each step in design and production of printed circuits; a buyer's guide to special components; and "how to" service data. Paperbound, illustrated. 192 pages. 1957. **$2.00**

Maintenance and Servicing of Electrical Instruments

by James Spencer. Useful to all instrument users, service men, switchboard attendants testing engineers, and others, this book covers construction, testing, applications, principles of operation and maintenance of all kinds of electrical indicating instruments. Clothbound, 274 illustrations, 280 pages. 1951 (third edition). **$2.00**

Process Control Analysis

by M. H. LaJoy and E. A. Baillif. An essential first step in analysis of closed-loop controlled processes via frequency response of the system. Clothbound, 72 pages. 1956. **$2.00**

Strain Gage Instrumentation

edited by Aronson and Nelson. " . . . a practical text . . . covers fundamentals, basic bridge circuits, typical applications, and surveys typical commercial instruments which use or are used with strain gages." Paper, 110 pages, illustrated, indexed by company, author, and subject. 1958. **$2.00**

100 Electronic Circuits

by M. H. Aronson and C. F. Kezer . . . covers amplifiers, oscillators, pulse circuits, phase shifters, etc. Complete with all circuit component values and response specifications. Paper, 180 pages, 1957. **$2.00**

Automatic Control Technology

—Modern Theory and Their Usefulness. Includes 90 advanced papers on control technology as delivered in original language (about ½ of book is in English). Cloth, 9 x 12", 508 pages, 1957. **$25.00**

Digital Techniques for Computation and Control

by Klein, Morgan and Aronson . . . all basic digital techniques within one text . . . code arithmetic, logical networks, multiplexing, conversion, data reduction, digital process control, two-terminal relay circuits, counting techniques, digital computers, programming, digital differential analyzers, and combined analog-digital equipments. Cloth, 394 pages, illustrated. 1958. **$6.00**

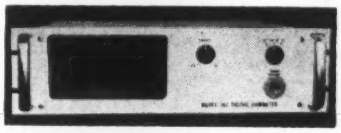
Instruments Publishing Co.

845 Ridge Avenue

Pittsburgh 12, Pa.

DIGITAL OHMMETER

New Model 781 Digital Ohmmeter features an illuminated readout and sound-insulated stepping switches.

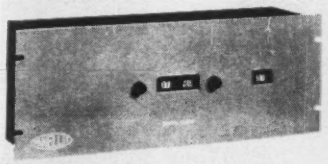


Five ranges are available from 0.1 to 10 megohms with an accuracy of 0.05% of reading +1 digit.—*Non Linear Systems, Inc., Del Mar, Calif.*

For more information circle **219** on inquiry card.

UNIVERSAL DIGITAL CLOCK

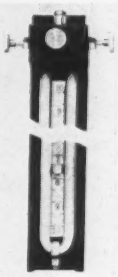
New Universal Digital Clock, Model 281, has visual indication and 3 independent decimal outputs which are all resolved to one sec. Three isolated electrical circuits provide simultaneous readout presented serially for tape punch, typewriter and 10-key adding machine, or presented in parallel for card punch, high-speed printers, and computer entry.—Bulletin 8-41 contains details.—*Panellit, Inc., 7401 No. Hamlin Ave., Skokie, Ill.*



For more information circle **220** on inquiry card.

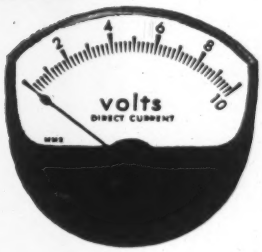
U-TUBE MANOMETERS

New U-Tube Manometers with an integral 3-valve bypass manifold (which facilitates operation) have a built-in shutoff valve for each of the two pressure lines, and a bypass valve in a connecting passage between. Two models are available: (1) single-cleanout, with a formed glass U-tube, comes in 8 sizes from 6" to 50" range, and (2) double-cleanout, with two straight glass tubes connected by a passage in a removable cleanout head at the bottom, which comes in 16 sizes from 6" to 130" range. All are available with wetted metal parts of carbon steel, brass, or stainless steel.—*King Engineering Corp., Box 690, Ann Arbor, Mich.*



For more information circle **218** on inquiry card.

marion
advancement in instrument design



MEDALIST* meters

Combine increased readability with attractive color styling. ASA/MIL 1½", 2½" and 3½" mounting. Up to 50% longer scale in same space as conventional types. Standard and special colors. Bulletin on request. Marion Electrical Instrument Co., Manchester, N. H., U. S. A. *A subsidiary of Minneapolis-Honeywell Regulator Company.*

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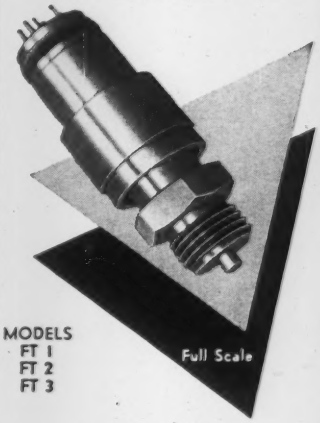
marion
"WHERE ELECTRONICS MEETS THE EYE"
meters
H HONEYWELL

For more information circle **110** on inquiry card.

Dynisco

FORCE TRANSDUCER



Incorporates Unbonded Strain Gauge

HIGHLIGHTS

- MEASURES BOTH TENSILE AND COMPRESSIVE FORCE
- FORCE PROBE DISPLACEMENT LESS THAN 0.00035 INCHES
- OVERALL ACCURACY BETTER THAN 1%
- VERY HIGH NATURAL FREQUENCY
- SMALL SIZE
- WEIGHS ONLY 2 OZ.

FORCE RANGES
0-5 to 0-2000 LBS

REQUEST BULLETIN NO. 111A

For more information on Dynisco pressure, force, flow, and displacement pickups, write:

DYNAMIC INSTRUMENT CO.
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Cambridge 42, Mass.
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For more information circle **109** on inquiry card.

GLASS CYLINDERS
RODS • TUBES
CIRCLES & SPECIAL SHAPES

EXPERIMENTAL and PRODUCTION BLOWING

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FABRICATED and CUT to Your SPECIFICATIONS

Glass Tubes and Rods for Scientific Use—Lamps, Furniture, Lighting & Decorative Fixtures—Display Domes—Contract Cutters of Tube and Rod.

CRYSTAL GLASS TUBE & CYLINDER CO.
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For more information circle **111** on inquiry card.

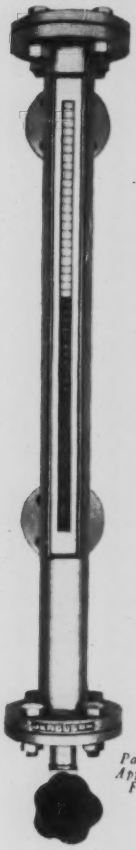
Announcing

the New

Jerguson

MAGNETIC GAGE

For Liquid Levels



An important advancement in liquid level observation for plants with dangerous explosive or inflammable conditions.

Safety design seals against escaping gases.

Measuring mechanism in stainless steel chamber.

Scale mounted outside chamber; magnetically actuated through chamber wall.

Distinct, accurate level shown in red contrasted with silver above.

Job designed, correlating pressure, temperature, and specific gravity.

Available with electric alarms.

Patent Applied For

Can also be used for interface indication.

Write now for engineering sheet on Jerguson Magnetic Gages.

JERGUSON

Gages and Valves for the Observation of Liquids and Levels

JERGUSON GAGE & VALVE COMPANY

100 Adams Street, Burlington, Mass.

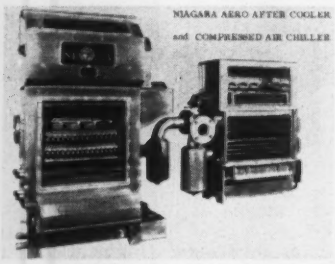
Offices in Major Cities

In Canada: Peacock Bros. Ltd.

For more information circle **112** on inquiry card.

AFTER COOLER AND CHILLER

New Aero After Cooler and Compressor Air Chiller remove moisture from the atmosphere or dirt or lubricating oil by first reducing temperature of compressor discharge to approximately that of the atmosphere, and then using refrigeration to cool and dry the air. A typical installation produces 45-deg air at 90-psig pressure, needing only 5 tons refrigeration for 900 cfm free air, resulting in air moisture of only 0.065 lb per 1000 cu ft.—*Niagara Blower Co., 405 Lexington Ave., New York 7, N. Y.*



For more information circle **221** on inquiry card.

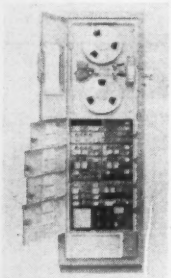
SYNCHRONISM INDICATOR

New Syncro-Scope engine synchronism indicator was developed to prevent destructive vibration in twin engine installation, indicating the degree of engine speed synchronism between two marine or airplane engines by a flashing glow light.—*Era Meter Co., 3932 N. Kilpatrick Ave., Chicago 41, Ill.*

For more information circle **222** on inquiry card.

INDUSTRIAL TAPE RECORDER

New Model FR-100 Magnetic Tape Recorder is specifically designed to record and reproduce scientific and industrial data for analysis and control applications. Has 1"-wide tape, six speeds, and can record on 14 parallel tracks.—*Ampex Corp., Instrumentation Div., Redwood City, Calif.*



For more information circle **223** on inquiry card.

OPTICS

LAMINATED & SOLID GLASS **FILTERS**
INDUSTRIAL • SCIENTIFIC • PHOTOGRAPHIC

PRECISION OPTICS
WINDOWS • PRISMS • WEDGES

SPECIALIZED GLASS
VYCOR • PYREX • QUARTZ

PRECISION HOLE DRILLING
TOLERANCES TO .0001"

PRECISION EDGING SAWING, MACHINING
ON ALL TYPES OF GLASS & CERAMICS

PRECISION **OPTICAL MACHINING**
METAL LENS MOUNTS • BARRELS • EYEPIECES

AUTOMATIC SCREW MACHINES TO 4" DIA. — ALSO HAND SCREW MACHINES — ENGLISH & METRIC THREADS OUR SPECIALTY.

Write for Filter Transmission Curve Catalog.

Tiffen QUALITY PRODUCTS

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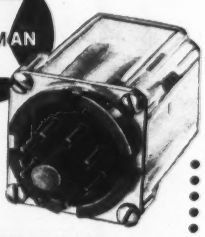
71 Jane St., Roslyn Heights, L.I., N.Y.

For more information circle **113** on inquiry card.

KURMAN



SERIES 26D 10 AMP.

KURMAN
MINIATURE POWER RELAY

FEATURES
- Clear polystyrene dust-proof enclosure
- Up to 3 P D T, 10 amp. contacts
- AC or DC coil, up to 15,000 ohms
- Life—100,000 operations minimum
- Dimensions 1⅜" sq. x 2¼" high
- Octal or 11 pin plug-in

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Quality Relays Since 1928
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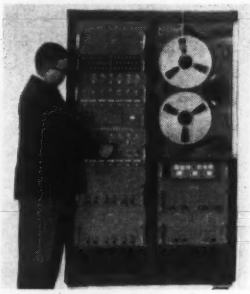
SEND FOR CATALOG

For more information circle **114** on inquiry card.

GROUND STATION RECORDERS

New telemetering Ground Station Instrumentation Tape Recorder, Model 707, features a start and stop time of less than 30 msec a frequency re-

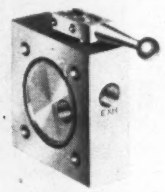


sponse to 130,000 cps and an output of 4vrms into 180 ohms. Plug-in modules provide direct analog, PDM and FM recording. Simultaneous recording and reproduction of 2 tracks may be had on ¼-in tape. ½-in tape models provide 7 tracks and 1-in models have 14 tracks.—*Midwestern Instruments, P. O. Box 7186, Tulsa, Okla.*

For more information circle **224** on inquiry card.

LEVER OPERATED VALVE

New lever-operated Slim Line valves, 1" thick by 3" wide, are suited for air, oil or water service; pres-

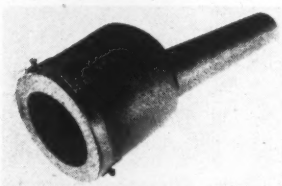


sures to 125 psi; temperatures to 150°F.; and are available tapped for either ⅛" or ¼" pipe connection, furnished 3-way or 4-way, manually operated both directions, or spring return.—*Hunt Valve Co., Salem, Ohio*

For more information circle **225** on inquiry card.

NETIC CO-NETIC SHIELD

New non-shock-sensitive, non-retentive Netic Co-Netic shield has improved resolution with maximum storage capacity in data storage tubes.



Both a-c and permanent-magnet fields are effectively shielded indefinitely at all operational levels; no periodic annealing is required.—31-page Manual 101-122 contains physical data and graphs.—*Perfection Mica Co., 1322 No. Elston Ave., Chicago 22, Ill.*

For more information circle **226** on inquiry card.

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New!
TRANSISTORIZED

The A. W. HAYDON COMPANY'S TRANSISTORIZED SUB-MINIATURE ELECTRONIC TIME DELAY RELAYS!

SAVE SPACE AND WEIGHT!

	Miniature Series	Sub-Miniature Series
Cross Section	17/16" x 121/32"	31/32" x 13/16"
Length	2¼" long	2" long
Weight	6 ounces	3 ounces
WRITE FOR:	Bulletin AWH TD-503	Bulletin AWH TD-504

TEST-PROVED PERFORMANCE!
High Temperature: 125°C (250°F)
Vibration: 2000 CPS at 15 g.
Contact arrangements up to 4 pole double throw.
Unique transistorized R.C. time constant network.
Time Delays from 50 MS to 120 seconds. Longer Delays available.
Hermetically sealed housings.

MEET REQUIREMENTS OF MIL-E-5272A.

The A. W. HAYDON Company
224 NORTH ELM STREET, WATERBURY 20, CONNECTICUT
Design and Manufacture of Electro-Mechanical Timing Devices

For more information circle **115** on inquiry card.

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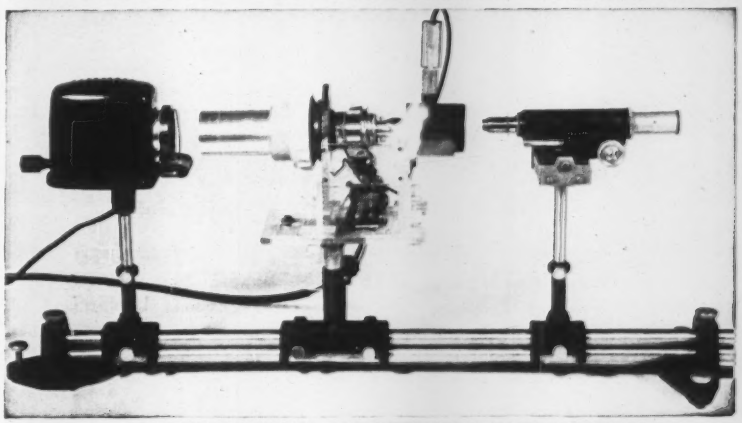

the UNIVERSAL INSTRUMENT BENCH

The Universal Instrument Bench is a basic tool for general research, experimentation, testing, measurement, and production in the Electronic, Electrical, and Optical fields. By employing its component parts, an almost unlimited number of instrumentation devices can be quickly assembled. These devices can be used for assembly line testing of finished equipment, assemblies, and components—making mock-ups and trial tests of proposed instruments—precise alignments and measurements.

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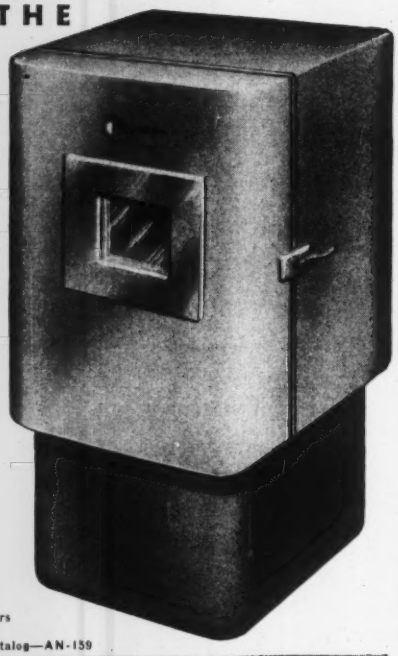

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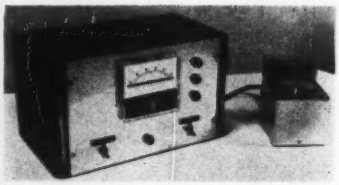
NEW INSTRUMENTS

ROUGHNESS METER

New Vibra-Meter developed by R&D Labs of New Departure Div., General Motors, evaluates smoothness running quality of precision in-

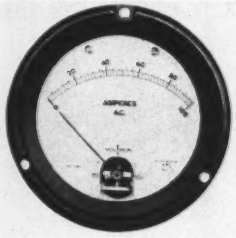


strument ball bearings by converting the axial component of forces into an electrical signal, and using an average-reading meter and three peak level trigger circuits.—*Leitch-Huard Corp., Stark and Commercial Sts., Manchester, N. H.*

For more information circle **227** on inquiry card.

LINEAR AC AMMETER

New linear A-c Ammeter provides 2% accuracy at any part of scale over frequency range 300 to 2000 cps. Hermetically sealed, it meets environ-

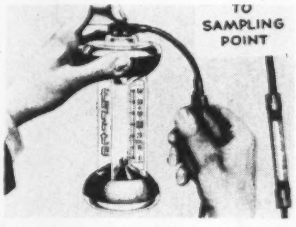


mental requirements of MIL-M-10304A. Unit is self-contained up to 10 amp and uses external current transformer above this range.—*Volttron Products, 1010 Mission St., South Pasadena, Calif.*

For more information circle **228** on inquiry card.

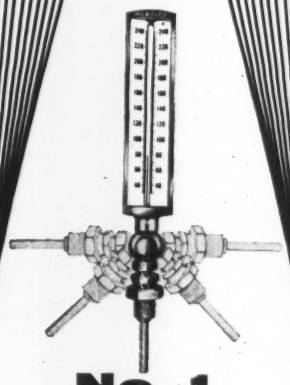
PORTABLE GAS ANALYZER

New portable Orsat-type Gas Analyzer in Fyrite line measures 0 to 60% CO_2 in exhaust gases of kilns, heat-treating atmospheres, brewing



tanks, inert atmospheres in tanks, pressurized chambers where foods are stored, and protective atmospheres used in many industrial processes. No special cooling means are required.—*Bacharach Industrial Instrument Co., 200 N. Braddock Ave., Pittsburgh 8, Pa.*

For more information circle **229** on inquiry card.



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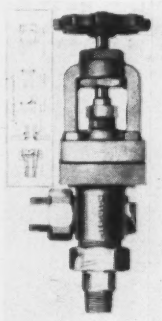
For more information circle **119** on inquiry card.

OS&Y VALVES

New Outside Screw & Yoke Bolted Bonnet valves for use with liquid level gages and instruments are available for all pressures in a variety of styles,

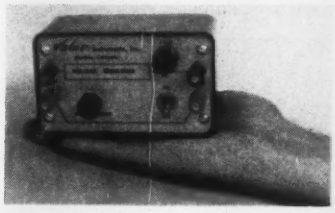


which include offset, double-union and jacketed valves. They have renewable seats and stainless-steel trim.—*Jerguson Gage & Valve Co., 80 Adams St., Burlington, Mass.*

For more information circle **230** on inquiry card.

VOLTAGE REGULATOR

New small regulator provides voltage regulation, low output impedance, and variable voltages from fixed-voltage unregulated d-c supplies. Operates from a nominal 28-v d-c supply. Out-

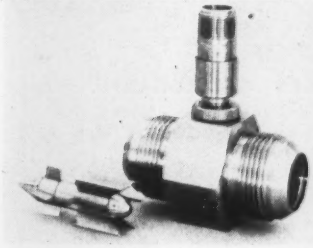


put is 6 to 20 vdc at ½ amp. Regulator makes use of germanium transistors for regulation and silicon Zener diodes for reference.—*Valor Instruments, Inc., 13214 Crenshaw Blvd., Gardena, Calif.*

For more information circle **231** on inquiry card.

FLOW PICK-UP

New Fluid Bearing Flow Sensor determines fluid velocity in a constant-area passage containing a spinning turbine rotor supported entirely by



a fluid film, which serves as a bearing. Ranges of 10:1 are obtainable with an accuracy of ¼% of actual flow rate.—*Waugh Engineering Co., 7842 Burnett Ave., Van Nuys, Calif.*

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CONTROL PANELS

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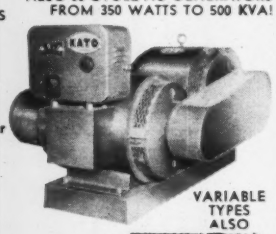

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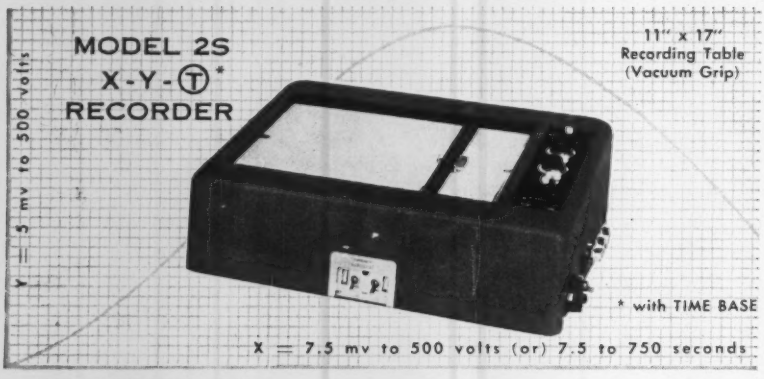
For more information circle **121** on inquiry card.



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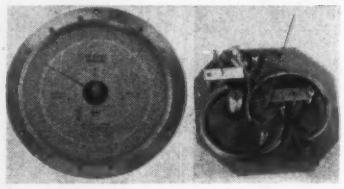
For more information circle **122** on inquiry card.

NEW INSTRUMENTS

DUAL BOURDON GAGES

New pressure gage has two Ni-Span C Bourdon tubes inter-connected by a novel ratio linkage to permit measurement of absolute and differential pressures up to 500 psi. For

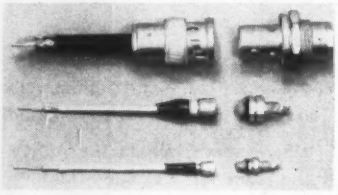


absolute-pressure work, one Bourdon tube is evacuated and serves as the zero pressure reference. For differential pressures, each system pressure is connected to a separate bourdon tube. Accuracy is better than 0.2% of full scale.—Bulletin TP gives details.—*Wallace & Tiernan Incorporated*, 25 *Main St., Belleville 9, N. J.*

For more information circle **233** on inquiry card.

COAXIAL CONNECTOR

New "sub-microminiature" Coax Connector is $\frac{1}{25}$th the over-all size of a standard BNC connector with $\frac{1}{50}$th

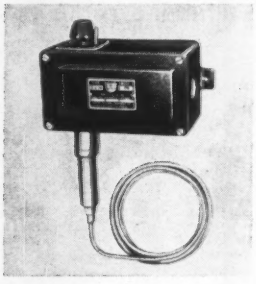


of the weight. Samples are available. —*Microdot, Inc.*, 220 *Pasadena Ave., South Pasadena, Calif.*

For more information circle **234** on inquiry card.

PRESSURE VACUUM CONTROL

New Type J95 explosion-proof control is an uncalibrated unit. Pressure settings are made by means of an internal adjusting nut between the lim-

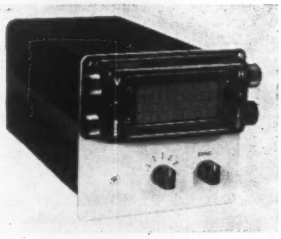


its of 0 and 500 psig and maximum pressures of up to 600 psig. Cast-iron enclosure permits use in Class I, Groups C & D; Class II, Groups E, F & G; and Class III.—*United Electric Controls Co., Watertown, Mass.*

For more information circle **235** on inquiry card.

MEDICAL OSCILLOSCOPE

New Medic Panelscope, Model P1B1X8, specifically designed for medical electronic applications, portrays EKG, EEG, and other physi-



ological phenomena. The built-in signal (vertical) amplifier has a sensitivity of 2.4 mv rms/in and a frequency response from dc to 50 kc.—*Waterman Products Co., Inc., 2445 Emerald St., Phila. 25, Pa.*

For more information circle **236** on inquiry card.

LIQUID-LEVEL SWITCH

New Liquid-Level Switch has a hermetically-sealed beta source and a beta detector mounted in a sensing probe which can be located up to 200 ft from the fully transistorized completely epoxy-potted amplifier, connected by a miniature 50-ohm, Teflon-insulated coaxial cable.—*Robertshaw-Fulton Controls Co., Aeronautical and Instrument Div., Anaheim, Calif.*

For more information circle **237** on inquiry card.

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MULTIMETERS® and REGULAR METERS
AC and DC types, multiple ranges, accuracy — ½ of 1%. 2 microamperes to 1 ampere DC. 2 milliamperes to 3 amperes AC.

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For more information circle **123** on inquiry card.

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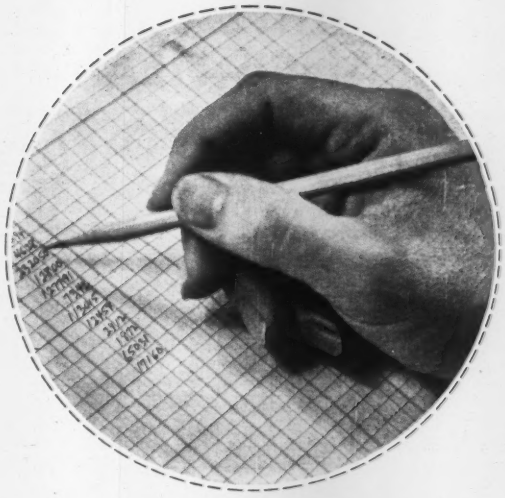

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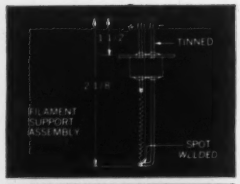

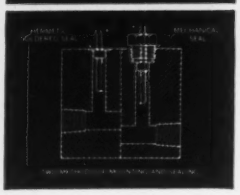

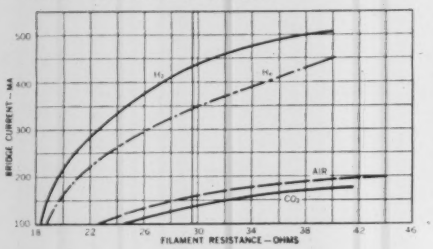

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Incorporates laboratory-standard meter with 7-inch custom-calibrated mirror scale. Ranges: 10MV to 500 RMS volts full scale. Input Z: 1 meg. Freq. Response: 50-2000 cps. Accuracy: ¼%-½% of full scale. Power: 115 VAC, 50-400 cps. Price $985.00.

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when ordinary instruments are too big or inadequate . . .

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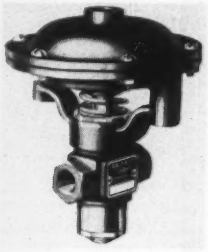
For more information circle **126** on inquiry card.

NEW INSTRUMENTS

CONTROL VALVES

New diaphragm-operated control valves, designed for actuation by any 3-way pilot valve, instrument control, cycle controller or process timer, are suitable for use in air, oil or vacuum

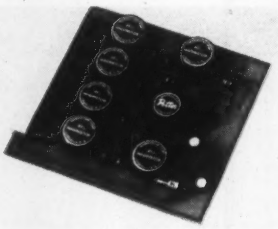


circuits. Actuator can be used with any combination of 2-, 3- or 4-way Valvair valve bodies. Port sizes range from ¼" through 1" NPT.—*Valvair Corp.*, 454 *Morgan Ave., Akron* 11, *Ohio*

For more information circle **238** on inquiry card.

TRANSIENT-PERMANENT MAGNISTOR

New MPT-1 Magnistor, a solid-state magnetic component composed of inert materials, is an 8-terminal device, whose 4 windings provide data storage (SET); dissipate the stored magnetism (RESET); and furnish complementary effects of each of two



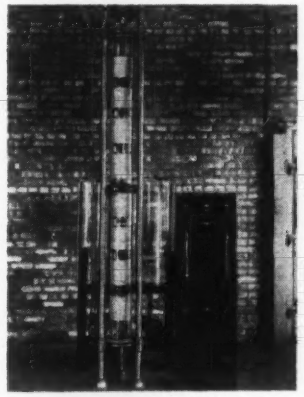
other windings, with respect to the other, when considered in combination (INTERROGATE and R.F.). Picture shows application in alpha-numeric character module for storage, comparison, coincidence detection and solenoid drive in high-speed page printer—*Potter Instrument Co., Inc. Sunnyside Blvd., Plainview, L.I., N. Y.*

For more information circle **239** on inquiry card.

SOLVENT EXTRACTION COLUMN

New Spiradyne Column Extraction Plant, a completely engineered packaged assembly, tailor-made to customers requirements, with a choice of either manual or automatic operational controls, is intended for pilot plant investigations or small scale production. Available in capacities ranging from 20cc/min to 20 gpm, the plant consists of a gravity-type column with impeller mixing sections

assembled on a rotating shaft for intimate contacting of two phases. The clarification sections are packed

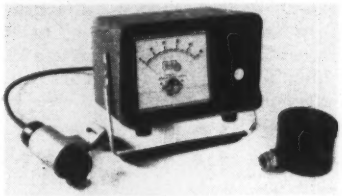


with coalescing materials necessary for phase disengagement.—*Podbielniak, Inc., Dept. S,* 341 *East Ohio St., Chicago* 11, *Ill.*

For more information circle **240** on inquiry card.

ELECTRONIC TACHOMETERS

New ET-series Electronic Tachometers include models for specific applications covering a variety of ranges from 0.1 to over 1,000,000 rpm full

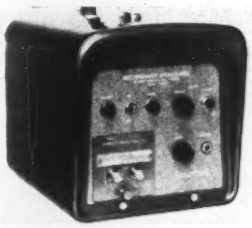


scale. They are widely applicable for measuring rotation or linear speeds of conveyors, motors, pumps, machine tools, mills and turbine, jet and reciprocating engines.—*Southwestern Industrial Electronics Co.,* 10201 *Westheimer, Houston, Texas*

For more information circle **241** on inquiry card.

PRESSURE STANDARD

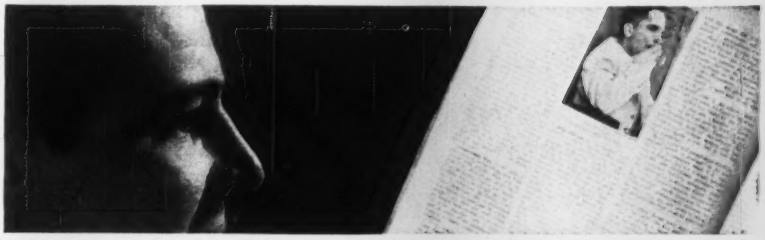
New portable Secondary Standard, Type Q3401, for calibration and direct parameter measurement has an overall accuracy of 0.05% for ranges up



to 2500 psig, psid, or psia as it incorporates a precision FM oscillator and an integral power supply.—4-page Bulletin 106 gives details.—*Wiancko Engineering Co.,* 255 *No. Halstead Ave., Pasadena, Calif.*

For more information circle **242** on inquiry card.

NEW . . . FROM api
THE PANEL METER WITH THE BUILT-IN

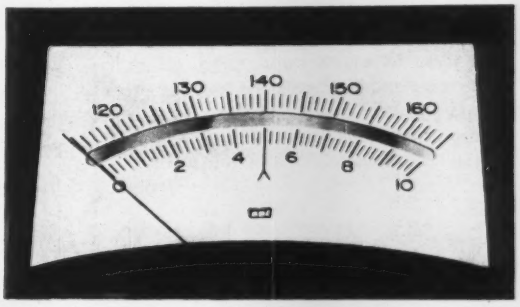


NATURAL READING ANGLE

Here is the newest, freshest meter styling idea in years: The A.P.I. Model 561 . . . the slim, trim panel meter with the longer, larger dial you read like a book. Subtly recessed and correctly sloped at the natural reading angle, this meter gives you 30% more dial area in 15% less panel space. Back-of-panel mounting neatly conceals the meter movement; only the clean, crisp façade of the dial is exposed, a clear picture window.

Installation is easier done than said. The 5″ x 2⅞″ case frame is self-trimming, requires a simple panel cutout—no holes to drill, no stud alignment troubles. A window in the meter case provides for dial illumination; you can save a bit of work (and panel space) by using the dial light as a pilot.

For the man who needs a smaller meter, there's the Model 361, an identical but diminutive companion to the Model 561. It measures just 3½″ x 2″. Both models are molded of satin-finish Bakelite, and both can be had in ranges of 0-5 microamperes to 0-50 amperes or 0-5 millivolts to 0-500 volts.



MORE INFORMATION? SEND FOR DATA SHEET 10-A

ASSEMBLY PRODUCTS, INC.
Chesterland 10, Ohio

S.A. 1057

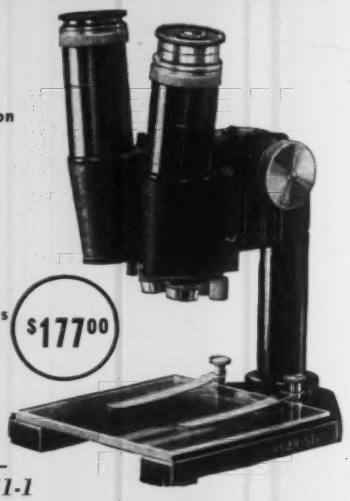
For more information circle **127** on inquiry card.

Leitz STEREO MICROSCOPE

FOR CRITICAL INSPECTION OR ASSEMBLY

Operations on Miniature or Routine Parts

- Improved Optics to Eliminate Eye Strain Even in Continuous Operation
- Extra Wide Field by Oversize Eyepieces,
- Long Working Distance for Assembly Operations
- 100% Unit Construction



$177.00

**Modest Price—*
Request Catalog 51-1

OPTO-METRIC TOOLS, INC.
137 IA VARICK STREET, NEW YORK 13, N. Y.

For more information circle **128** on inquiry card.

3 ELEMENT
SPEED SENSITIVE SWITCHES

DIMENSIONS . . . 2⅝" Dia. x 6" Long
WEIGHT . . . . . 1¾ lbs.

Synchro-Start Model GA-3 speed sensitive switches are suitable for installation on AND20005 aircraft tachometer drive pad.

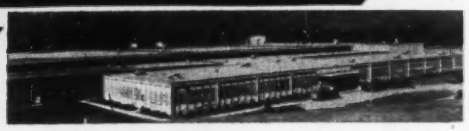
These units are adjustable while running, splash proof, and have a flexible drive shaft to compensate for mounting misalignment. They can be supplied to open or close 3 separate circuits at any speeds between 1,200 and 6,000 RPM in the standard governor. Special speeds either above or below the standard model must be referred to our Engineering Department.

Other governors with 1 and 2 switches are available with a variation of mountings for tachometer cable and SAE coupling drives.

SYNCHRO-START PRODUCTS, INC.
8151 NORTH RIDGEWAY AVENUE, SKOKIE, ILLINOIS
Manufacturers of
AUTOMATIC ENGINE CONTROLS • SPECIAL CONTROL PANELS
SAFETY ALARM SETS • D.C. SOLENOIDS • HEAVY DUTY RELAYS

For more information circle **129** on inquiry card.

new plants and mergers



CORNING GLASS WORKS has started operation of its new multimillion-dollar plant in Bradford, Pa.; manufacturing glass electronic components.

BARDEN CORP. recently unveiled its new $2,500,000 plant for the manufacture of precision ball bearings.

KEARFOTT COMPANY announced recently the creation of its Components Div. in Clifton, N. J. This autonomous operation will be devoted to the manufacture of servo system components.

ZENITH OPTICAL LAB announces expansion of its Ultrasonic Drilling and Grinding Division at Copiague, N. Y.

GENERAL PRECISION LAB has announced the formation of two new groups within its Avionic Divisions in an expansion move marking its entry into the field of commercial aviation equipment. The groups are: Commercial Avionic Sales and Commercial Avionic Engineering.

WESTON INSTRUMENTS, Div. of Daystrom, Inc. has opened four sales offices in New York State: Buffalo, Syracuse, Albany and Rochester.

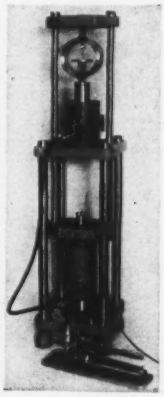
WARNER & SWASEY CO. announces that the Warner & Swasey Research Corp. has been made the Control Instrument Div. of the company with headquarters for sales engineering and manufacturing in New York City.

INACCURACY IS COSTLY!

check your

THRUST STANDS
TESTING MACHINES
DYNAMOMETERS
WEIGHING SYSTEMS

with MOREHOUSE PROVING RINGS



Inaccurate force measurement systems waste time and money. For maximum accuracy, be sure to calibrate your systems regularly with a MOREHOUSE PROVING RING . . . the industry standard for over 30 years. Every MOREHOUSE PROVING RING is calibrated and certified by the National Bureau of Standards.

The MOREHOUSE UNIVERSAL CALIBRATING MACHINE (left) facilitates the calibration of compression and tension type load cells in capacities ranging from 10,000 lb. to 100,000 lb.

Learn the construction, operation and application of proving rings . . . write today for the 16 page book, "THE A B C's of ACCURACY."

MOREHOUSE MACHINE CO.
1742 Sixth Avenue • York, Pa.

For more information circle **130** on inquiry card.

people in the news

D. E. Moat
L&N

N. Cohn
L&N

J. D. Saint-Amour
API

LEEDS & NORTHRUP'S president, *I. Melville Stein*, announces three top management appointments: *Nathan Cohn* fills a new post, vice president—technical affairs; *Donald E. Moat*, becames vice president—marketing; and *John F. Quereau* becomes vice president—manufacturing.

METRONIX, INC., a wholly-owned subsidiary of Assembly Products, announces that its president, *John D. Saint-Amour*, has also assumed the duties of sales manager.

ROBERTSHAW-FULTON CONTROLS announces appointment of *George Schatzman* as director of the fluid controls department and *John W. Gillings* to the newly-created position of director of product planning.

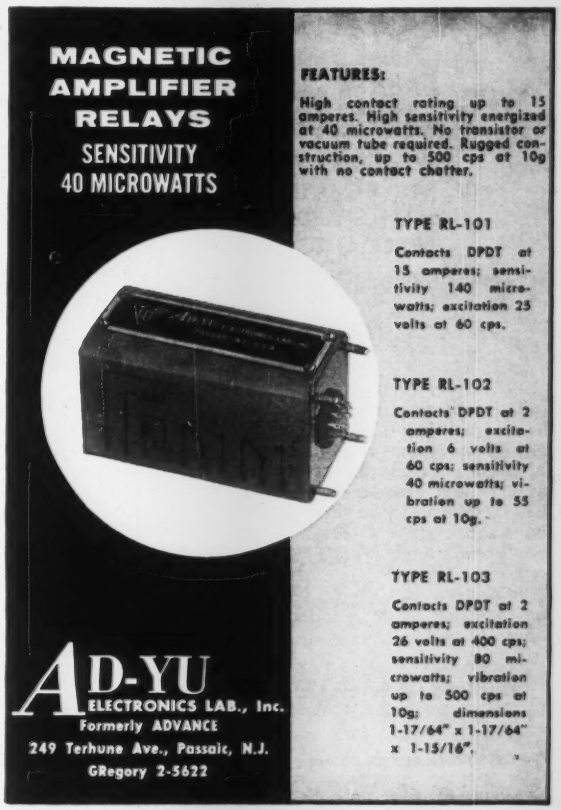
TRIPLETT ELECTRICAL INSTRUMENT CO.'S founder and chairman of the board *R. L. Triplett*, observed his 75th birthday anniversary, November 13.

C. P. CLARE & CO. has announced the appointment of *Alvin E. Weill* as director of laboratory services.

CURTISS-WRIGHT announces appointment of *Edward Bachor* as assistant chief engineer of the Electronics Div.

new
miniature
DC RELAY
with full size contacts
TYPE Z
AVAILABLE WITH PRINTED CIRCUIT TABS
Ideal for applications requiring compactness, sensitivity, easy mounting and economy. Features full-size contacts. Can be supplied with tabs for printed circuit use. Send for details.
COMAR
ELECTRIC COMPANY
3349 ADDISON ST., CHICAGO 18, ILL.
RELAYS • SOLENOIDS • COILS • SWITCHES • HERMETIC SEALING

For more information circle **131** on inquiry card.


MAGNETIC AMPLIFIER RELAYS
SENSITIVITY 40 MICROWATTS
FEATURES:
High contact rating up to 15 amperes. High sensitivity energized at 40 microwatts. No transistor or vacuum tube required. Rugged construction, up to 500 cps at 10g with no contact chatter.
TYPE RL-101
Contacts DPDT at 15 amperes; sensitivity 140 microwatts; excitation 25 volts at 60 cps.
TYPE RL-102
Contacts DPDT at 2 amperes; excitation 6 volts at 60 cps; sensitivity 40 microwatts; vibration up to 55 cps at 10g.
TYPE RL-103
Contacts DPDT at 2 amperes; excitation 26 volts at 400 cps; sensitivity 80 microwatts; vibration up to 500 cps at 10g; dimensions 1-17/64" x 1-17/64" x 1-15/16".
AD-YU
ELECTRONICS LAB., Inc.
Formerly ADVANCE
249 Terhune Ave., Passaic, N.J.
GRegory 2-5622

For more information circle **132** on inquiry card.

MODEL 96-451C. 96 channel strain vs. load plotter with automatic servo gun balance.

The B & F "c" system shown here plots strain vs. load for each channel on a continuous paper loop. It can be obtained with a digital readout and strains can be tabulated on a typewriter, IBM cards or punched tape.

Unusual design and construction features—exclusive with B & F systems—provide complete versatility by the utilization of modular construction and separate gage factor and range setting controls for each channel. Strain is read directly regardless of gage resistance, number of active arms, gage factor or length of input cable.

Write, wire or call for the new bulletin illustrating and describing the many other advantages.

B&F instruments, Inc.

Manufacturers of: Strain Gage and Transducer Conditioning Equipment, Torque Meters, Accelerometers

3644 N. LAWRENCE STREET, PHILADELPHIA 40, PA. • GArfield 5-4175

For more information circle **133** on inquiry card.

USE **dekatron**®

COUNTING TUBES FOR RELIABLE, HIGH SPEED COUNTING APPLICATIONS

Baird-Atomic uses DEKATRON glow transfer tubes in all instruments where counting and read-out are required. A typical application is the Atomic Instrument Line's Model 134 Scaler for ultra-high speed counting of beta and gamma radioactivity . . . up to 1,000,000 counts/minute! The input circuit incorporates a fast, constant-sensitivity Schmitt discriminator driving a beam switching decade with glow tube read-out . . . 6 DEKATRONS.

You too, can count on DEKATRON for reliable performance. For detailed information request Data Sheet IC 4001.

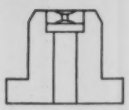
Baird-Atomic, Inc.
33 UNIVERSITY RD., CAMBRIDGE 38, MASS

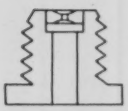
Instrumentation for Better Analysis

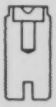
For more information circle **134** on inquiry card.

PRECISION JEWEL BEARING ASSEMBLIES . . .

for AIRCRAFT • ELECTRICAL MECHANICAL and MARINE INSTRUMENTS







Sapphires set in brass, or other metal assemblies made in any quantity to close tolerance specifications are produced by Moser Jewel Company—*manufacturers of industrial jewels for over 50 years.*

Moser also provides highly polished pivots, staffs —silicon and spring loaded assemblies for high shock resistance.

SEND SPECIFICATIONS — DETAILED INFORMATION READILY GIVEN.

MOSER JEWEL COMPANY

P.O. Box 150 • Perth Amboy, N. J.

"Manufacturers of all types of Industrial Jewels"

For more information circle **135** on inquiry card.

PEOPLE—CONTINUED

T. Clements

J. Kleiman

E. Bollay

HICKOK ELECTRICAL INSTRUMENT CO. announces appointment of *Thomas Clements* as manager of test equipment sales.

TELECOMPUTING CORP. has named *Joseph Kleiman* vice president and general manager of the Whittaker Gyro Div.

BJ ELECTRONICS, BORG-WARNER CORP. announces appointment of *Eugene Bollay*, internationally-known meteorologist, as director of research, meteorology instrumentation.

STROMBERG-CARLSON has appointed *Dr. Donald G. Wilson* general manager of the San Diego facility of the company's Electronics Div.

FRANKLIN ELECTRONICS announces formation of a new west coast division, called the Communication and Controls Division, in Van Nuys, Calif. Head of the new west coast division is *Dr. Martin L. Klein*, well-known for his numerous technical articles and the text *Digital Techniques for Computation and Control* (Instruments Publishing Co.)

HANKISON CONDENSIFILTERS

REDUCE *maintenance*
MAINTAIN *accuracy*

in pneumatic instruments, controls, and machinery

- **CONDENSE** oil and moisture vapors—for maximum protection of pneumatic systems
- **SEPARATE** entrained liquids—preventing corrosion and sluggish equipment
- **FILTER** contaminant solids—scale, rust, dirt, with disposable cartridge
- **DISCHARGE** all condensates and entrainments with built-in, automatic Mag-Pneu-Power Trap

Capacities: M-100T, 100 scfm at 100 psig; M-30T, 30 scfm at 100 psig. Both models of rugged construction, require only 1 hour per year servicing.

WRITE FOR BULLETIN 4158

HANKISON CORPORATION

College & Pike Canonsburg, Penna.

For more information circle **136** on inquiry card.

D. G. Wilson

M. L. Klein

J. Hussey

BERKELEY DIV. of Beckman Instruments announces that *Joseph Hussey* has been appointed manager of engineering.

CONSOLIDATED ELECTRODYNAMICS has changed the name of its Central Manufacturing Div. to the Electro Mechanical Instrument Div. and announces the following appointments: *A. P. Stuhrman*, director, *John P. Moffat, Jr.*, chief engineer; *Henry S. Black*, director of the Data-Tape Div.; *Donald E. Stocking*, sales manager, Rochester Div.

MILLARD D. SHRIVER CO. is a new sales and engineering company representing Panellit and others in California. *Mr. Shriver* formerly was vice president of Panellit, Inc.

A. P. Stuhrman D. E. Stocking H. S. Black M. D. Shriver

FOR LEAK-DETECTION DEVICES

OHIO

NITROUS OXIDE

EASILY SNIFFS OUT MICROSCOPIC LEAKS

Infrared determination of nitrous oxide provides a safe, sensitive and flexible method of leak detection. This method is not affected by usual atmosphere components such as moisture, carbon dioxide and hydrocarbons. In addition, nitrous oxide will not harm pieces being tested and is more economical than other gaseous agents.

OHIO NITROUS OXIDE: ODORLESS AND INERT • NONTOXIC • NONCORROSIVE • NONFLAMMABLE • ECONOMICAL

FREE TECHNICAL AID is available in the use of nitrous oxide for leak detection. For further information, please request the following bulletins:

1A Chemical, Physical and Pharmacological Properties of Nitrous Oxide with Results of Corrosion Tests

1B Gas Service Equipment for Nitrous Oxide Supply

OHIO *Ohio Chemical*

OHIO CHEMICAL & SURGICAL EQUIPMENT CO.

(A Division of Air Reduction Company, Incorporated) AIRCO

MADISON 10, WISCONSIN

For more information circle **137** on inquiry card.

New **GAGE GARD JR.**

protects sensitive low-pressure instruments

Here's *positive* protection for low-pressure-range instruments — incline manometers, draft gauges, electrical pressure switches, ultra-sensitive low-pressure transducers, and many others!

GAGE GARD JR. is applicable to either atmospheric or relative pressure systems. It's available in four ranges, covering the span of −15 PSIG to +85 PSIG. It will withstand after-cutoff pressure up to 300 PSI.

(For higher-range protectors—up to 9,000 PSIG—ask about GG-1 and GG-2.)

GAGE GARD JR. is repeatable. It reopens after sealing at 2% below the cut-off point. You can adjust and reset the cutoff pressure point at any time, or order it factory-set.

Weighs only 11 ounces! Body material is aluminum; diaphragm is buna-S impregnated with nylon.

Write for Bulletin 547G for complete details and prices.

INDUSTRIAL IEC ENGINEERING CORP.

INDUSTRIAL ENGINEERING CORPORATION

529 E. Woodbine, Louisville 8, Kentucky

Designers, engineers, and manufacturers of hydraulic and electronic test equipment, consoles, panels, etc.

For more information circle **138** on inquiry card.

STANDARDS ENGINEER

Large industrial test laboratory requires a standards engineer to develop and evaluate test methods and procedures for the calibration of measuring instruments. Requires a BS degree and 4 to 6 years experience in electrical or physical standards measurement, electronic instrumentation and environmental equipment calibration. Experience in microwave measurement techniques desirable.

As a major manufacturer of electronic and electromechanical devices and as a long term prime contractor for the AEC, Bendix of Kansas City offers a truly outstanding opportunity. Salary commensurate with ability and experience. Numerous company benefits. Re-location expenses paid, of course.

Plant is adjacent to Kansas City's finest, newest residential areas; short drive to work, no traffic problems. Numerous, modern, highly-rated schools. Favorable climate, many cultural and recreational facilities contribute to pleasant living. Bendix offers assistance program for engineers who desire graduate study at local universities.

Your inquiry strictly confidential. Airmail brief resume at once to Mr. T. H. Tillman, Professional Personnel, Bendix Box 303-ES, Kansas City, Missouri.

Bendix AVIATION CORPORATION

KANSAS CITY, MISSOURI

ADAMS FACT FILE #3

INSTRUMENT AIR

Clean Dry Air Supply Will Reduce Production Down-Time . . . Instrument Maintenance . . .

Wet, dirty compressed air has no place in the process industries. In instrument air supply lines it can cause havoc. Whether it be motor air in a control circuit or supply air to the control panel, absolutely clean dry air is vital. Moisture elimination is the major consideration in providing suitable air for instrument and control systems.

Since most plant compressors in use today are oil lubricated, a finite amount of oil is present with the water vapor in the discharge. This carry-over condenses as an oil-water emulsion which often causes serious fouling of instrument components. To eliminate this oil-moisture condensate in the air lines, it is necessary to remove it before it reaches the distribution system. This is done by cooling the air before the receiver. It is advisable to cool well below the ambient conditions to provide the lowest possible humidity at the instrument panel or control units.

Two Stage System Design for Economy

The ideal method to achieve high quality air is a two-step operation.

1—An Adams Aftercooler . . . providing 2° F. cooling . . . and Cyclone Separator installed between the compressor and receiver to remove the bulk of moisture carry-over.

2 — A chemical dryer installed down stream to provide the polishing action necessary for the desired minimum humidity.

Thus, the bulk of water . . . 90% . . . is removed by the Aftercooler-Separator using plant water for cooling. A minimum moisture load is then left to be removed by more expensive methods. Under normal circumstances, all of the oil present in the compressor discharge will be removed in the Aftercooler-Separator. Fouling of the chemical unit is then virtually eliminated.

Poro-Stone Air Filter at Panel Provides Dirt-Free Control Air . . .

In spite of the efficiency of the Adams Aftercooler and Separator, there still will be some dust and dirt present in the instrument air system. That's why it is advisable to install an Adams Poro-Stone Air Filter in the line just before the control panel.

Separation by the Adams unit is in two stages — centrifugal and diffusion. Centrifugal force throws the foreign matter to the walls of the filter body where it is trapped in slots and drained. Remaining particulate matter is removed as the air passes through the pores of the Poro-Stone element.

This final protection for your instruments will minimize control system failures and process down-time. Instrument maintenance will be sharply reduced.

Literature Will Help Air System Design

For further information on how the complete line of Adams air equipment can help you provide a foolproof instrument air supply, write today for your copy of Bulletin No. 712 on Aftercoolers and Separators and Bulletin No. 117 on Poro-Stone Air Filters to the R. P. Adams Company, Inc., 265 East Park Drive, Buffalo 17, New York.

For Bulletin 712 circle **141** on inquiry card.
For Bulletin 117 circle **142** on inquiry card.

new literature

ELECTRICAL, ELECTRONIC INSTRUMENTS

DEFLECTION POTENTIOMETERS. 6-page Data Sheet E-51 (8) describes Brooks Deflection Potentiometers which speed calibration and checking of ammeters, milliammeters, microammeters and voltmeters.—Leeds & Northrup Co., 4934 Stenton Ave., Phila. 44, Pa.

For more information circle **243** on inquiry card.

DIGITAL VOLTMETER. 2-page Data Sheet 19-24 describes Model 402 AC/DC Digital Voltmeter.—Kin Tel, Div. of Cohu Electronics, 5725 Kearny Villa Rd., Box 623, San Diego 12, Calif.

For more information circle **244** on inquiry card.

PANEL METERS. 6-page Bulletin GEA-6678 describes in text, pictures and tables, new "Big Look" in small panel instruments (both 2½" and 3½" models), d-c and a-c.—General Electric Co., Schenectady 5, N. Y.

For more information circle **245** on inquiry card.

DIGITAL VOLT-OHMETER. 4-page Bulletin 400A describes a new precision digital VTVM for lab and OEM use, and demonstrates theory of operation by means of a functional block diagram and a brief discussion.—Frankline Electronics Inc., Bridgeport, Montgomery County, Penna.

For more information circle **246** on inquiry card.

CONTACT METER/CONTROLLER. 2-page leaflet describes with pictures, diagrams and specifications new C'trol package for accurate control of systems or equipment.—Waters Manufacturing, Inc., Wayland, Mass.

For more information circle **247** on inquiry card.

PHASE SEQUENCE INDICATOR. 2-page Bulletin 1550 illustrates and describes new low-cost portable phase sequence indicator.—Opad Electric Co., 69 Murray St., New York 7, N. Y.

For more information circle **248** on inquiry card.

SEISMOGRAPH. 4-page pocket size folder illustrates and describes Model 8000 Explorer all-transistorized seismograph system.—Texas Instruments Inc., Industrial Instrumentation Div., 3609 Buffalo Speedway, Houston, Texas.

For more information circle **249** on inquiry card.

RESISTANCE BRIDGE INDICATOR 4-page brochure furnishes information for users of strain gages, load cells, resistance thermometers, pressure transducers, or other resistance bridge transducers.—Datran Electronics, 1836 Rosecrans Ave., Manhattan Beach, Calif.

For more information circle **250** on inquiry card.

PHASE METERS. 4-page bulletin illustrates and specifies 10 types of phase meters, 16 types of time delays, counters, etc.—Ad-Yu Electronics Lab., Inc., 249 Terhune Ave., Passaic, N. J.

For more information circle **251** on inquiry card.

For your library . . .

Printed Circuitry

by Allan Lytel. A valuable working tool; includes alternative and recommended practice for each step in design and production of printed circuits; a buyer's guide to special components; and "how to" service data. Paperboard, illustrated, 192 pages, 1957. $2.00

Maintenance and Servicing of Electrical Instruments

by James Spencer. Useful to all instrument users, service men, switchboard attendants testing engineers, and others, this book covers construction, testing, applications, principles of operation and maintenance of all kinds of electrical indicating instruments. Clothbound, 274 illustrations, 280 pages, 1951 (third edition). $2.00

The Automatic Factory

by June, et al . . . a fresh viewpoint on what "manless factories" can be . . . free from the generalities, and misconceptions so prevalent on this subject. Cloth, 88 pages, 1955. $1.50

Nuclear Reactors for Industry and Universities

edited by E. H. Wakefield. The several distinguished authors and editor Wakefield cover types, availability (1954), operation, protection, control, experiments, legal aspects, and present a detailed cost study. Cloth, 92 pages, illustrated, 1954. $2.00

Process Control

by A. J. Young. A "must" for all who have to do with the automatic control of industrial processes, this book combines for the first time the practical "how" and the theoretical "why". Paperbound, 134 pages, 1957 (second printing). $2.00

Operation and Care of Circular-Scale Instruments

by James Spencer. Includes "trouble" charts for d-c, and for a-c instruments; covers d-c instruments, a-c ammeters and voltmeters, wattmeters, frequency meters, power factor meters and synchroscopes. Clothbound, 90 pages, 1949. $1.50

Control Valves

by C. S. Beard. New "one-book" reference on control valves . . . covers flow characteristics; mechanical features; valve capacity; sizing; body types; positioners; actuators, including d-c, electrohydraulic and gas hydraulic actuators. Numerous tables and illustrations. Paperbound, 236 pages, 1957. $2.00

Instruments Publishing Co.

845 Ridge Avenue
Pittsburgh 12, Pa.

VERTICAL SCALE INDICATOR. Bulletin R-60 gives a technical report on the ATC Vertical Scale Indicator used with Atcotran differential transformers to display linear measurements of such variables as pressure, motion, liquid level, thickness, etc.—Automatic Timing & Controls, Inc., Dept. 210, King of Prussia, Penna.

For more information circle **252** on inquiry card.

ELECTRONIC READOUT. 2-page bulletin describes electronic readout, originally developed as a precision tachometer readout, which with proper transducers, can provide direct readings for many applications.—Deltime, Inc., 608 Fayette Ave., Mamaroneck, N. Y.

For more information circle **253** on inquiry card.

AUTOMATION

CENTRALIZED CONTROL SYSTEMS. 16-page Bulletin 106 illustrates and describes design approach, materials, construction and facilities used in manufacturing a variety of centralized control and data presentation systems.—Panellit, Inc., 7401 No. Hamlin Ave., Skokie, Ill.

For more information circle **254** on inquiry card.

PROCESS INSTRUMENTS. 52-page Catalog 2 covers indicators, transmitters, recorders and controllers for flow, pressure, temperature, density, viscosity and consistency, available for quick shipment.—Fischer & Porter Co., 941 Jacksonville Rd., Hatboro, Penna.

For more information circle **255** on inquiry card.

PHOTOELECTRIC CONTROLS. 4-page Catalog 58-1 describes controls with cad cell sensing element; with transistor and with magnetic amplifier, including suitable light sources.—Autotron, Inc., Box 722 Q, Danville, Ill.

For more information circle **256** on inquiry card.

MOTORS SERVOS

SERVO MOTORS. 10-page Bulletin 385A contains applications data for standard and custom servo motors.—Ketay Department, Norden Division, United Aircraft Corp., Commack, L. I., N. Y.

For more information circle **257** on inquiry card.

SERVO SYSTEM COMPONENTS. 8-page Bulletin 36100 illustrates and describes construction and principle of operation of electrohydraulic servo valves.—The Oilgear Co., 1560 West Pierce St., Milwaukee 4, Wis.

For more information circle **258** on inquiry card.

VALVES

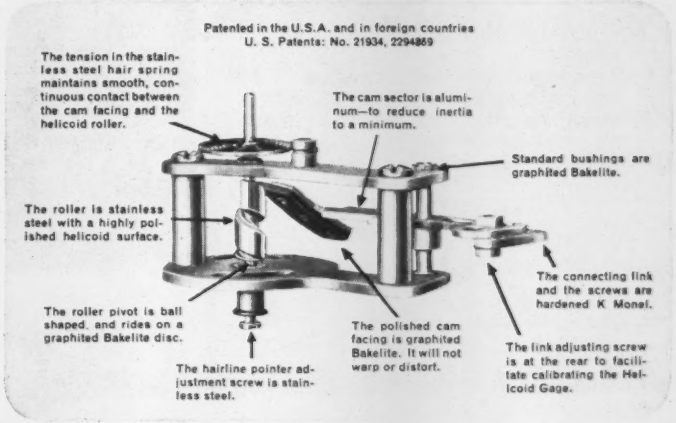
DIAPHRAGM CONTROL VALVES, single-seated, are described with specs in new 14-page bulletin 5304.—Leslie Co., Lyndhurst, N. J.

For more information circle **259** on inquiry card.

ACCO Helicoid Gage U.S.A.

Nothing but the best in gages for working pressures from 30" vacuum to 10,000 p.s.i.

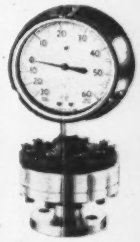
These details of Helicoid gage design assure longer life and enduring accuracy


Patented in the U.S.A. and in foreign countries
U. S. Patents: No. 21934, 2294869
The tension in the stainless steel hair spring maintains smooth, continuous contact between the cam facing and the helicoid roller.
The cam sector is aluminum—to reduce inertia to a minimum.
Standard bushings are graphited Bakelite.
The roller is stainless steel with a highly polished helicoid surface.
The connecting link and the screws are hardened K Monel.
The roller pivot is ball shaped, and rides on a graphited Bakelite disc.
The polished cam facing is graphited Bakelite. It will not warp or distort.
The link adjusting screw is at the rear to facilitate calibrating the Helicoid Gage.
The hairline pointer adjustment screw is stainless steel.

The superiority of Helicoid Gages is most evident in severe service—wherever a gage is subjected to violent pressure pulsations or severe mechanical vibrations.

The *sustained accuracy* of Helicoid Gages over *millions of cycles* is explained by the details of design and construction of the Helicoid movement shown above. Such Helicoid features—protect against wear and corrosion and assure sensitivity, sustained accuracy and trouble-free operation.

The Chemical Gage



The Helicoid Chemical Gage has a guaranteed accuracy of plus or minus 1%. It is applicable for working pressures from 30" vacuum to 5000 p.s.i. and temperatures to 400° F. It is particularly suitable for chemicals and other viscous fluids which might clog or corrode a Bourdon tube. Pressure and/or vacuum is transmitted directly to the indicating gage element through deflection of a Teflon or Kel F sealing diaphragm.

Tubes built for millions of pressure pulsations

To fit the wide range of applications, Helicoid Bourdon tubes are available in four materials—alloy steel, K Monel, stainless steel and phosphor bronze.

All Helicoid tubes are made from seamless tubing and are carefully designed to give maximum torque and minimum stress. When used within the dial range, they will withstand many millions of pressure pulsations and will not stretch, leak or crack.

For complete information on the Helicoid line of gages write for **Catalog G-52**

Helicoid gives you all these features at prices that are competitive in the quality gage field.

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For more information circle **143** on inquiry card.

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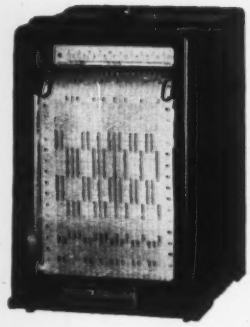

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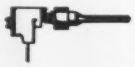
For more information circle **146** on inquiry card.

NEW LITERATURE

INSTRUMENT VALVES. 4-page Bulletin 571 gives step-by-step description of carbon-steel and stainless-steel forged valves.—Edward Valves, Inc., Subsidiary of Rockwell Mfg. Co., East Chicago, Ind.
For more information circle **260** on inquiry card.

SOLENOID VALVES. 12-page Catalog 2000 of high-pressure solenoid valves for hydraulic power systems includes two-way and three-way valves in both a-c and d-c models.—Waterman Engineering Co., 725 Custer Ave., Evanston, Ill.
For more information circle **261** on inquiry card.



TEMPERATURE

DIAL THERMOMETERS. 12-page Catalog 205 describes and illustrates new Supertherm line of dial thermometers.—United States Gauge, Div. of American Machine and Metals, Inc., Sellersville, Penna.
For more information circle **262** on inquiry card.

THERMOCOUPLE PROBE. 12-page Bulletin EDS-36, describes cermet-shielded, high-temperature thermocouple probe.—Thermo Electric Co., Inc., Saddle Brook, N. J.
For more information circle **263** on inquiry card.

TEMPERATURE INSTRUMENTS. 60-page, Constant-Temperature Catalog 500 describing a complete line of baths, conditioned-air devices, temperature-humidity cabinets, dry-ice cabinets and various types of thermometers, includes temperature-conversion table (C to F).—American Instrument Co., Inc., 8030 Georgia Ave., Silver Spring, Md.
For more information circle **264** on inquiry card.

FLOW, LEVEL

FLOW AND LEVEL METERS. Wall poster illustrates and describes fuel measuring systems with remote read-out and control; and tank measuring systems.—Pottermeter Co., Div. of Potter Aeronautical Corp., U. S. Route #22, Union, N. J.
For more information circle **265** on inquiry card.

ROTAMETERS. 4-page Bulletin 19A describes metal tube rotameters for hazardous and high-pressure fluids.—Schutte and Koerting Co., Instrument Div., Cornwells Heights, Bucks County, Penna.
For more information circle **266** on inquiry card.

WEIGHT, PRESSURE

AUTOMATED BLENDING. 6-page Bulletin 715 describes how the Ohio Rubber Co. uses the fully-automated "Select-O-Weigh" proportioning system to provide a custom rubber production service.—Richardson Scale Co., Clifton, N. J.
For more information circle **267** on inquiry card.

PRESSURE TRANSDUCER. 4-page catalog describes and specifies Model S-30 pressure transducer.—Ultradyne, Inc., P. O. Box 3308, Albuquerque, N. M.

For more information circle **268** on inquiry card.

TIME, COUNT

INTERVAL TIMERS. 4-page Bulletin 400 describes with dimensions and wiring arrangements 5 series of synchronous-motor-driven timers with automatic and manual reset, respectively.—Industrial Timer Corp., 1407 McCarter Highway, Newark 4, N. J.

For more information circle **269** on inquiry card.

VARIABLE-SPEED DRIVE. 8-page Brochure S-580 provides data on non-electronic drives for industrial equipment motor control from ¼ hp to 1½ hp.—Magnetic Amplifiers, Inc., 632 Tinton Ave., New York 55, N. Y.

For more information circle **270** on inquiry card.

ELECTROMAGNETIC COUNTERS. 32-page booklet illustrates, dimensions and specifies German-made Elmeg Counters.—Presin Co., 2014 Broadway, Santa Monica, Calif.

For more information circle **271** on inquiry card.

LABORATORY, ANALYTICAL

CONTINUOUS STREAM ANALYZER. 8-page Bulletin CL-4000, describes process stream analyzers, including industrial pH equipment, industrial gas chromatographs, infrared analyzers, oxygen analyzers, and others.—Beckman/Scientific and Process Instruments Div., 2500 Fullerton Rd., Fullerton, Calif.

For more information circle **272** on inquiry card.

X-RAY INSTRUMENTS. 12-page Booklet RC 212A covers the latest x-ray instruments for element analysis and structure determination.—Philips Electronics, Inc., Instruments Div., 750 South Fulton Ave., Mount Vernon, N. Y.

For more information circle **273** on inquiry card.

PLASTIC LABORATORY WARE. 20-page Catalog G358 features products molded from Polypropylene (Nalgene PR), etc.—Scientific Plastics, Div. of Wisconsin Science Supply Co., 1419 Underwood Ave., P. O. Box 74, Milwaukee 13, Wis.

For more information circle **274** on inquiry card.

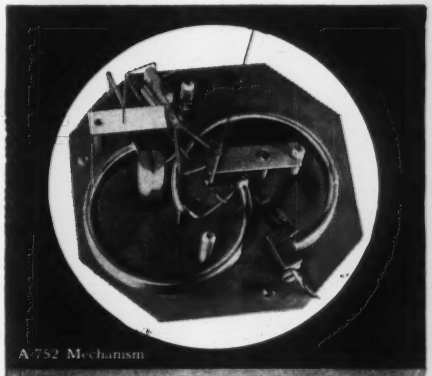
LABWARE. 8-page Bulletin TP-1 describes lower-priced Teflon laboratory products.—Kontes Glass Co., Vineland, N. J.

For more information circle **275** on inquiry card.

NUCLEONICS

MANIPULATORS. 20-page booklet describes new devices for remotely handling radioactive, toxic or highly-flammable materials.—Nuclear Equipment Dept., Mechanical Div. of General Mills, Inc., 1620 Central Ave., Minneapolis 13, Minn.

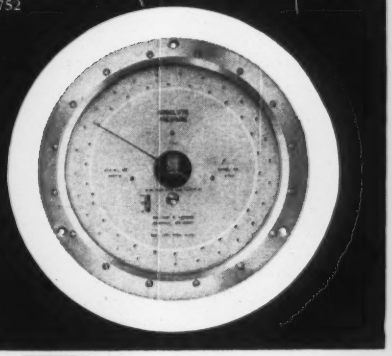
For more information circle **276** on inquiry card.



A-752 Mechanism

NEW W&T BOURDON TUBE GAUGE

A-752



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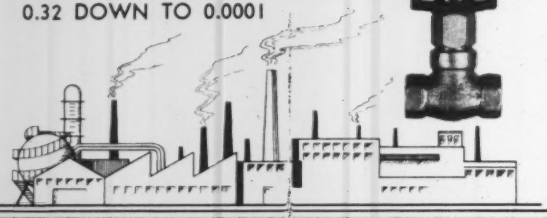

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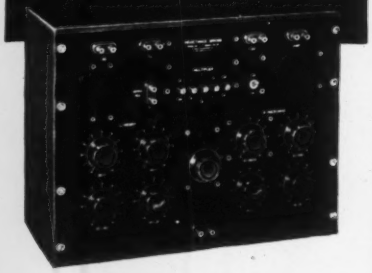

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For more information circle **151** on inquiry card.

NEW LITERATURE

NUCLEAR INSTRUMENTATION for medicine, industry, research etc., is described in new 56-page manual.—Radiation Counter Labs., Inc., 5121 W. Grove St., Skokie, Ill.

For more information circle **277** on inquiry card.

YIELD DETERMINATION. 4-page Technical Bulletin No. 1 outlines use of radioisotopes in yield determination, a common quantitative analysis.—Nuclear-Chicago Corp., 229 West Erie St., Chicago 10, Ill.

For more information circle **278** on inquiry card.

OPTICAL

COORDINATE COMPARATOR. 2-page Bulletin 181-58 describes the coordinate comparator for measuring x-ray plates, spectrograms, star photographs, charged particle tracks, and similar records on photographic plates.—Gaertner Scientific Corp., 1201 Wrightwood Ave., Chicago 14, Ill.

For more information circle **279** on inquiry card.

ELECTRON-OPTICAL Instruments are described in new 16-page engineering data booklet RC178A.—Philips Electronics, Inc., Instruments Div., 750 South Fulton Ave., Mount Vernon, N. Y.

For more information circle **280** on inquiry card.

DATA HANDLING

PRE-PATCH PANEL. 4-page Bulletin AC839 and four 2-page preliminary information sheets provide details on panel, function generator cards, etc. for Type 231R analog computer.—Electronic Associates, Inc., Long Branch, N. J.

For more information circle **281** on inquiry card.

DIGITAL INDICATOR/PRINTER. 2-page bulletin describes features, applications, and specifications of Digital Indicator and Printer Model 176.—Gilmore Industries, Inc., 13015 Woodland Ave., Cleveland 20, Ohio

For more information circle **282** on inquiry card.

DATA REDUCTION INSTRUMENTS. 22-page spiral binder provides descriptive information for digital voltmeters, d-c amplifiers, automatic range-switching controls, scanners, commutators, etc.—Electronic Computer Co., 618 Maple St., Conshohocken, Penna.

For more information circle **283** on inquiry card.

RANDOM ACCESS STORE. 4-page Bulletin 58-B contains description and specifications of Model 3122 storage equipment.—Rese Engineering, Inc., 731 Arch St., Phila. 6, Pa.

For more information circle **284** on inquiry card.

DIGITAL TEST EQUIPMENT. 4-page data folder provides specifications and prices for transistorized digital test equipment.—Digital Equipment Corp., Maynard, Mass.

For more information circle **285** on inquiry card.

TAPE PROCESSING EQUIPMENT. 6-page brochure describes special equipment including tape tester, tape interrogate, tape editor, tape translator or tape copier.—Digitronics Corp., Albertson, L. I., N. Y.

For more information circle **286** on inquiry card.

DESKTOP COMPUTER. 4-page Data File 340 describes Model 3400 desktop analog computer.—Donner Scientific Co., Concord, Calif.

For more information circle **287** on inquiry card.

RECORDING

SPECIAL CHARTS. Bulletin, Y1906, describes charts for special requirements (including pre-printed photo charts for oscillographic recording). Engineering information and chart samples are included.—The Bristol Company, Waterbury 20, Conn.

For more information circle **288** on inquiry card.

PHOTO TOOLS. 128 page Catalog 958AR of over one thousand nationally famous items, both imported and domestic, includes cameras of every description; a most comprehensive list of lenses from ¼" to 72" of all speeds; projectors; printing equipment; new solar enlargers; lighting and developing equipment laboratory equipment, graphic arts, etc.—Burke and James, Inc., 321 S. Wabash Ave., Chicago 4, Ill.

For more information circle **289** on inquiry card.

LIGHTWEIGHT TAPE RECORDER. 8-page Model AR-100 product brochure provides information on magnetic tape recorder for mobile or airborne applications.—Ampex Corp., 934 Charter St., Redwood City, Calif.

For more information circle **290** on inquiry card.

ROUND-CHART RECORDERS. 4-page "Wheelco Comments", Vol. 23, No. 3, contains description of new recorders, recorder/controllers, indicators, and indicator controllers.—Wheelco Instruments Div., Barber-Colman Co., Rockford, Ill.

For more information circle **291** on inquiry card.

TESTING, GAGING

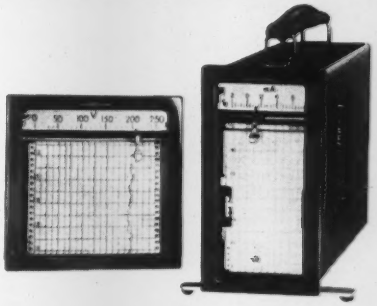
TENSILE TESTER. 6-page "CRE Tensile Tester Bulletin" describes tensile elongation tester for stress-strain evaluation of all materials.—Scott Testers, Inc., 45 Blackstone St., Providence, R. I.

For more information circle **292** on inquiry card.

TUBE TESTER. 8-page Bulletin 1230 gives step-by-step description of Cardmatic automatic tester.—Hickok Electrical Instrument Co., 10514 Dupont Ave., Cleveland 8, Ohio.

For more information circle **293** on inquiry card.

MINIATURE, STANDARD and DOUBLE SIZES!



MINIATURE RECORDERS

Square Model 85, in flush mount, weighs 16 lbs. and is 5⅝" square x 12¾" deep. Slim models 86 (portable) and 87 (flush) save half the width of standard recorders . . . measure 3¾" x 7⅛" x 8¾" and weigh only 9 lbs.

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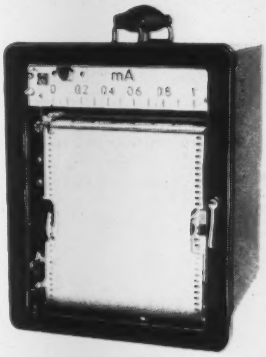

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Model 81 (portable) and 82 (flush) are also available for wall and projection mounting . . . take up to 3 channels. Weigh only 19 lbs. and measure 7½" x 9 13/16" x 7⅞".

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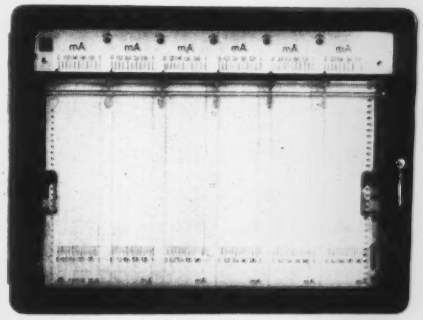

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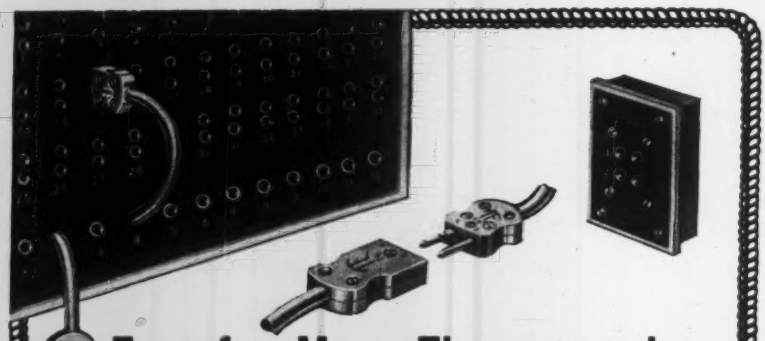

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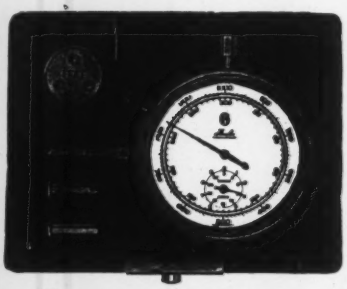

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For more information circle **155** on inquiry card.

NEW LITERATURE

THREAD COMPARATORS. 20-page Circular 606 describes thread comparators.—Pratt & Whitney Co. Inc., Charter Oak Blvd., West Hartford 1, Conn.

For more information circle **294** on inquiry card.

FM ANALYSIS. 8-page "The Panoramic Analyzer", Vol. 1, No. 4, outlines uses of FM commercially and in the missile aircraft field.—Panoramic Radio Products, Inc., 514 South Fulton Ave., Mount Vernon, N. Y.

For more information circle **295** on inquiry card.

MICROHARDNESS TESTERS. 2-page bulletin describes new low-cost microhardness tester that permits direct, accurate readings, corresponding to Vickers.—Newage Industries, Inc., 222 York Rd., Jenkintown, Penna.

For more information circle **296** on inquiry card.

ENVIRONMENTAL TESTING. 25-page booklet describes environmental testing laboratory facilities, which provide for the complete evaluation and testing of all types of commercial and military equipment.—The Belock Instrument Corp., College Point 56, N. Y.

For more information circle **297** on inquiry card.

SERVO TESTING. 42-page bound catalog describes theory and method of synchro and resolver testing.—Theta Instrument Corp., 48 Pine St., East Paterson, N. J.

For more information circle **298** on inquiry card.

TUBING, FITTINGS

TUBULAR PRODUCTS. 16-page Bulletin 12 illustrates, describes and tabulates many types of stainless-steel, nickel, nickel-alloy, and special-alloy tubing and fabricated parts.—J. Bishop & Co., Malvern, Penna.

For more information circle **299** on inquiry card.

STAINLESS STEEL FITTINGS. 54-page Catalog TT600 contains data on the full line of stainless-steel welding fittings and flanges.—Tube Turns, Louisville, Ky.

For more information circle **300** on inquiry card.

ELECTRONIC TUBES

R-F PENTODES. 2-page Bulletin E-315 gives specs, transfer characteristics, and rating curves of three sharp-cut-off-type tubes, designated 3DK6, 4DK6 and 6DK6.—CBS-Hytron, Parker St., Newburyport, Mass.

For more information circle **301** on inquiry card.

ELECTRONIC TUBES. 6-page Catalog 2220, gives specifications on complete line of electronic tubes for industry and communications.—Central Electronics Manufacturers, Denville, N. J.

For more information circle **302** on inquiry card.

POWER SUPPLIES

POWER SUPPLIES. 36-page Catalog 59 details full specs and data of some 40 regulated power supplies.—Lambda Electronics Corp., 11-11 131st St., College Point 56, N. Y.

For more information circle **303** on inquiry card.

RECTIFIER POWER UNITS. 10-page catalog describes on selenium and silicon rectifier power units.—Syntron Co., 669 Lexington Ave., Homer City, Penna.

For more information circle **304** on inquiry card.

ELECTRICAL, ELECTRONIC COMPONENTS

CERAMIC TRANSDUCERS. 8-page Bulletin X-103 describes applications of high-temperature, piezoelectric ceramic transducers in the fields of underwater sound, ultrasonics, medicine, shock and vibration, etc.—Gulton Industries, Inc., Advanced Development and Systems Div., 212 Durham Ave., Metuchen, N. J.

For more information circle **305** on inquiry card.

ELECTRONIC COMPONENTS. 48-page Catalog 159 describes Bud line of sheet metal products and electronic components; also special fabrication facilities are outlined.—Bud Radio, Inc., 2118 East 55th St., Cleveland 3, Ohio

For more information circle **306** on inquiry card.

VOLTAGE VARIABLE CAPACITOR 2-page Bulletin SR-205 gives engineering data of Semicap, high-Q voltage-sensitive variable capacitor.—International Rectifier Corp., El Segundo, Calif.

For more information circle **307** on inquiry card.

MOUNTING HARDWARE. 2-page specification sheet illustrates end mounting brackets, side mounting brackets, clip brackets and panel mounting accessories for Trimpot and Trimit potentiometers.—Bourns Laboratories, Inc., P. O. Box 2112, Riverside, Calif.

For more information circle **308** on inquiry card.

MAGNETIC AMPLIFIERS. 4-page Bulletin 401-A describes standard series 400-cps precision magnetic amplifiers for missile guidance, automatic pilots, industrial controls, monitoring systems, etc.—Acromag, Incorporated, 22519 Telegraph Rd., Detroit 41, Mich.

For more information circle **309** on inquiry card.

POLARIZED RELAYS. 8-page Bulletin 7279 contains control-system suggestions and possible applications of polarized relays.—Barber-Colman Co., Electrical Components Div., Rockford, Ill.

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DELAY LINES. 2-page data sheet gives dimensions and characteristic data of precision delay lines.—Valor Instruments, Inc., 13214 Crenshaw Blvd., Gardena, Calif.

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PULSE TRANSFORMERS. 2-page technical bulletin describes a series of miniature encapsulated pulse transformers wound on high permeability ferromagnetic cores.—Technitrol Engineering Co., 1952 E. Allegheny Ave., Phila. 34, Pa.

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CHOPPER. 4-page bulletin explains the operation and application of Model 60 solid-state electronic chopper.—Solid State Electronics Co., 8158 Orion Ave., Van Nuys, Calif.

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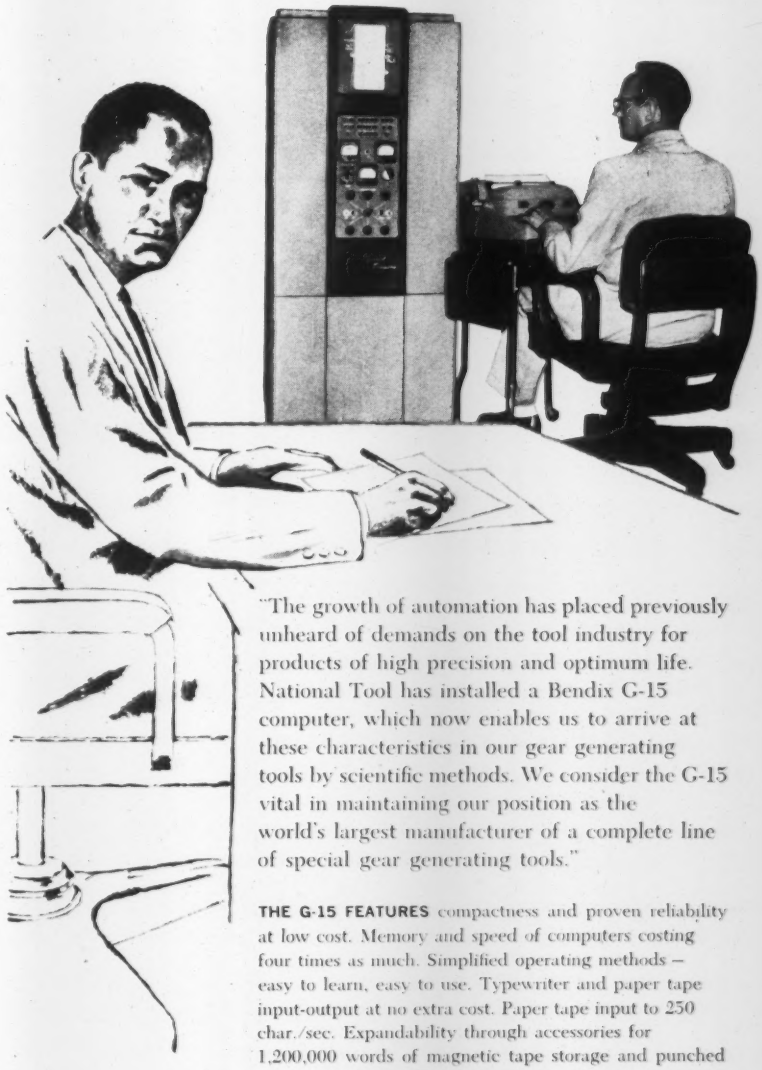

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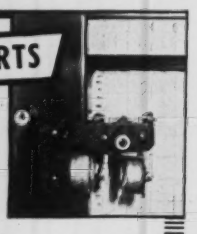

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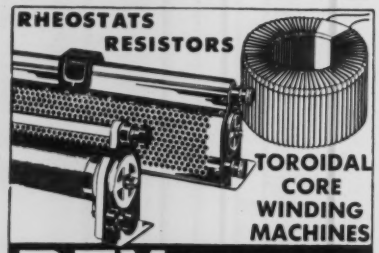

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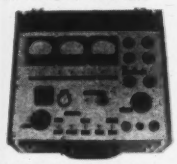

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WAVEGUIDE DATA CHART. Reference table of rigid rectangular waveguide data and fittings covers sizes from WR10 to WR2300.—Microwave Development Labs. Inc., 92 Broad St., Babson Park 57, Wellesley, Mass.

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ANODES, PLATING CHEMICALS. 8-page Bulletin AC-111 describes a complete line of anodes and plating chemicals.—Hanson-Van Winkle-Munning Co., Matawan, N. J.

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CONNECTORS, CABLE, WIRE

R-F CONNECTORS. 8-page "Amphenol Engineering News," Vol. 11, No. 5, contains an article on cable assembly techniques.—Amphenol Electronics Corp., 1830 South 54th Ave., Chicago 50, Ill.

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CONTROL CABLE. 6-page folder lists specifications on plastic-insulated and jacketed control cable with 600-v rating.—Chester Cable Corp., 121 Oakland Ave., Chester, N. Y.

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HIGH-TEMPERATURE WIRE. 8-page technical bulletin on "Ceramatemp" a ready-to-use, flexible, ceramic-type insulated wire rated for continuous operation at 1000°F, contains descriptive information.—Hitemp Wires, Inc., 1200 Shames Dr., Westbury, N. Y.

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TERMINAL BLOCK. 2-page catalog sheet gives specifications, dimensions and general information on new Series 200-19 plug and socket terminal block for heavy duty applications.—DeJur-Amsco Corp., 45-01 Northern Blvd., Long Island City 1, N. Y.

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SHEATHED CABLE. 16-page catalog describes construction features of C-L-X sheathed cables.—Simplex Wire & Cable Co., Cambridge 39, Mass.

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MECHANICAL COMPONENTS

INSTRUMENT BEARINGS. 24-page Catalog 59 describes thin-section ball bearings, made in precision and ultra-precision grades.—Split Ballbearings, Div. of MPB, Inc., Lebanon, N. H.

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MECHANICAL STOPS. 2-page Technical Data Sheet K1480-10 gives description, mechanical characteristics, and application formulas of these synchro mounted components.—Kearfott Company Inc., 1378 Main Ave., Clifton, N. J.

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FINE-PITCH GEARS. 4-page bulletin describes and illustrates facilities for gear blanking, gear cutting, gear train and sub-assembly operations.—Juall Gear Co., Inc., 1108 Goffle Rd., Hawthorne, N. J.

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MARKING MACHINES. 9-page Catalog No. 9 illustrates and describes the latest models of automatic, semi-automatic and hand operated rotary marking machines including peripheral marking types.—The Acromark Co., 9-13 Morrell St., Elizabeth 4, N. J.

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ATOM MODELS. 8-page revised Bulletin 10a58 on LaPine-Leybold line of atom models according to Stuart and Briegleb includes a new cyclopropane-group carbon atom model; also description of walnut storage cabinet.—Arthur S. LaPine and Co., 6001 South Knox Ave., Chicago 29, Ill.

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INSULATED-WIRE MARKING. 4-page issue of the "Bodine Motorgram" Vol. 38, No. 6, features articles on the marking of insulated electric wire, and tape-controlled turret drilling.—Bodine Electric Co., 2500 W. Bradley Pl., Chicago 18, Ill.

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BREATHER FILTERS. 2-page Engineering Data Sheet 101 describes a line of 40-micron breather filters.—Bendix Aviation Corp., Bendix Filter Div., 434 W. 12 Mile Rd., Madison Heights, Mich.

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TOROIDAL WINDERS. 16-page Catalog 58 describes automatic semi-automatic and subminiature toroidal winders; tape winding machine, and permeameter.—Boesch Manufacturing Co., Inc., 45 River St., Danbury, Conn.

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MOISTURE ACCESSORIES. 2-page Bulletin 1848 gives facts on three accessories for moisture monitors.—Consolidated Electrodynamics Corp., Analytical & Control Instrument Div., 300 North Sierra Madre Villa, Pasadena, Calif.

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VIBRATION METER. 2-page technical bulletin WK-B-731A describes Type B-731A vibration meter.—Wayne Kerr Corp., P. O. Box 801, Phila. 5, Pa.

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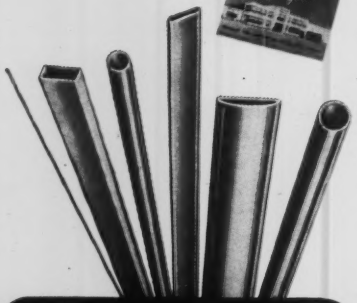

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advertisers index

This index is published as a service. Every care is taken to make it accurate, but I&A assumes no responsibility for errors or omissions.

Acton Laboratories, Inc. 128
Adams Company, Inc. R. P. 150
Ad-Yu Electronics Lab., Inc. 147
Alectric Manufacturing Co. 158
Allen-Bradley Co. 16
American Chain & Cable Co., Inc., Helicoid Gage Division 151
American Meter Company 33
Amperite 34
Assembly Products, Inc. 145
Automatic Switch Co. Inside Back Cover
Autotron, Inc. 135
Autotronics, Inc. 144

Bache & Company, Semon 140
Bailey Meter Company 54
Baird-Atomic, Inc. 125, 148
Barksdale Valves 50
Beede Electrical Instrument Co., Inc. 66
Bendix Aviation Corporation 149, 157
Berkeley Division, Beckman Instruments, Inc. 115
B & F Instruments, Inc. 147
Bridgeport Thermostat Division 45
Bristol Company 4, 28, 29, 158
Brush Instruments Division of Clevite Corporation 60
Bryant Chucking Grinder Co. 8
Burroughs Corporation, Electrodata Division 31

Cambridge Instrument Co., Inc. 41
Camera Equipment Company 20
Cannon Electric Co. 58
Clare & Co., C. P. 21
Clary Corporation 143
Clevite Corporation, Brush Instrument Division 60
Cobehn Inc. 42
Comar Electric Company 147
Conoflow Corporation 55
Consolidated Electrodynamics Corporation 53
Cox Instrument Division, Nankervis Co., George L. 12
Cramer Controls Corporation 46
Crystal Glass Tube & Cylinder Co. 137
Cubic Corporation 52
Curtiss-Wright Corporation 155

Dahl Company, Inc., George W. 128
De Zurik Sales Co. 158
Dialight Corporation 24
Du Mont Laboratories, Inc., Allen B. 43
Dwyer Mfg. Co., F. W. 132
Dynamic Instrument Co. 137

ElectroData Division of Burroughs Corporation 31
Electronic Associates Incorporated 112
Emery Company, A. H. 25
Eppley Laboratory, Inc. 135
ESC Corporation 11
Esterline-Angus Company, Inc. 152

Fenwal, Incorporated 39
Fisher Governor Company 59
Foxboro Company 36, 37, 56
Freed Transformer Co., Inc. 154

General Controls Co. Back Cover
General Electric Company 61
General Radio Company 13
Gow-Mac Instrument Co. 144
GPS Instrument Co., Inc. 117
Gray Instrument Company 122
Green Instrument Company, Inc. 130
Greibach Instruments Corporation 44
Gulton Industries, Inc. 129, 131, 133

Hagan Chemicals & Controls, Inc. 67, 69
Hankison Corporation 148
Hasler-Tel Co., Inc. 156
Haydon Company, A. W. 139
Heiland Division, Minneapolis-Honeywell Regulator Co. 62, 63
Helicoid Gage Division, American Chain & Cable Co., Inc. 151
Heise Bourdon Tube Company, Inc. 134
Hickok Electrical Instrument Co. 124

Ideal Industries, Inc. 2
Industrial Engineering Corporation 149
Instrument Service Engineering Labs. 158
International Register Company, Instrument Division 125
International Test Equipment Manufacturing Co. 140

Jamesbury Corp. 57
Jerguson Gage & Valve Company 138
Johnson Engineering Company, Inc., Welton V. 34
Jones Optical Works, A. D. 132

Kato Engineering Company 142
King Engineering Corp. 125
Kurman Electric Co. 138

Labline, Inc. 141
Larson Instrument Co. 150
Leach Corporation 22
Leeds & Northrup Company 70
Lepel High Frequency Laboratories, Inc. 123
Levin & Son, Inc., Louis 132
Lewis Engineering Co. 1
Librascope, Incorporated Inside Front Cover

Marion Electrical Instrument Co. 137
Marsh Instrument Co. 130
Marshalltown Mfg. Company 42
Marx Co., Clarence J. 158
Mine Safety Appliances Company 49
Moeller Instrument Company 130
Moore & Company, Samuel 14
Morehouse Machine Co. 146
Moseley Co., F. L. 142
Moser Jewel Company 148

Nankervis Co., George L., Cox Instruments Division 12
Nash Engineering Company 68
National Pneumatic Co., Inc. 159
Norwood Controls 35

Ohio Chemical & Surgical Equipment Co. 149
O. K. Machine & Tool Corporation 139
Opto-Metric Tools, Inc. 146

Pace Engineering Company 41
Packard Bell Electronics 19
Partlow Corp. 40
Pennsylvania Fluorocarbon Co., Inc. 136
Philadelphia Thermometer Co. 26
Physics Research Laboratories Inc. 5
Potter Instrument Company, Inc. 6
Power Designs Inc. 7
Precision Products, Inc. 122
Precision Tube Company 160
Pyro Service Co. 158
Pyrometer Instrument Co., Inc. 154

Radio Frequency Laboratories, Inc. 9, 120
Rawson Electrical Instrument Co. 143
Research Controls 154
Rex Rheostat Co. 158
Richard Rimbach Associates 38
Robertshaw-Fulton Controls Company, Aeronautical and Instrument Division 64
Royson Engineering 158

Sanborn Company 51
Scherr Co., Inc., George 135
Scott Testers, Inc. 122
Sensitive Research Instrument Corporation 2
Shore Instrument & Mfg. Co., Inc. 152
Stevens-Arnold, Incorporated 120
Sticht Co., Inc., Herman H. 158
Stromberg-Carlson 118
Superior Tube Company 65
Synchro-Start Products, Inc. 146

Technical Sales Corporation 10
Telecomputing Corp. 119
Teletype Corporation 47
Tenney Engineering, Inc. 17
Thermo Electric Co., Inc. 156
Tiffen Marketing Co. 138
Trans-Sonics, Inc. 126, 127
Trio Labs. Inc. 144
Triplett Electrical Instr. Co. 27

Uehling Instrument Co. 133
Unertl Optical Co., John 156
United Electric Controls Company 32
Universal Relay Corp. 152

Valcor Engineering Corp. 107
Veeder-Root Inc. 48

Wallace & Tiernan, Incorporated 153
Wekster Instruments Corp. 141
Welch Scientific Company, W. M. 121
Weston Instrument, Division of Daystrom, Inc. 23

Zeiss, Inc., Carl 26

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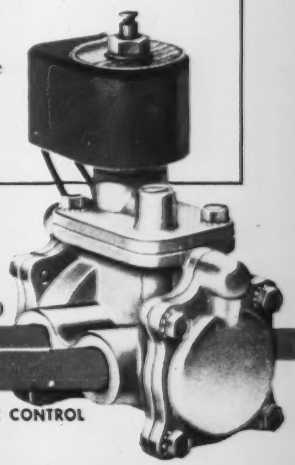

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